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Export investment under uncertainty: a mean-variance decision analysis for Indian manufacturing exporters

Subhadip Mukherjee[*], *Soumyatanu Mukherjee*[§], *Tapas Mishra*[‡†], *Udo Broll*[¶]

Abstract

This paper explores how much a domestic firm should optimally invest for facilitating export to the international market under uncertainty in nominal/spot exchange rate. We consider the presence of exogenous uncontrollable factors, influencing the fixed costs of exports and enhancing the uncertainty surrounding the exporting prospects. We categorise such additional randomness as a "background risk", affecting the choice variable (i.e. investment) independent of the endogenous exchange rate risk. In this context, we apply a mean-variance decision-theoretic modelling approach to analyse a risk-averse firm's optimal investment response to the changes in the distributions of the random spot exchange rate and of the background uncertainty, in terms of the relative trade-off between risk and return. Next, using an unbalanced panel data of 840 exporting Indian manufacturing firms over 17 years, we perform a structural estimation of the theoretical model, derived using a flexible utility function that incorporates all possible risk preferences, in order to demonstrate the key results in our model empirically. For this purpose, using fixed effects model and Heckman's two-step estimation procedure, we empirically estimate firm-level mark-up(s), as proxy for firms' risk-premium. This helps us to come up with the estimation of risk aversion elasticities in our context.

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1. Introduction

Cross-border flows of goods and services are one of the key components of the globalisation process. Increasing integration to the global market has significantly amplified firms' exposure to external shocks. The importance of firms' risk management has inspired an extensive empirical and theoretical literature on investment and production under uncertainty. Recent empirical evidence (see, for example, Nakhoda, 2018) puts emphasis 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 fact implies that the exporting firms of developing countries are generally risk-averse. Bloom et al. (2007) and Bloom (2009) have shown that the shocks pertaining to the volatility in the stock market reduce firm-level investment and mitigate its response to demand shocks. Handley and Limão (2015) have demonstrated the importance of trade policy uncertainty on firm-level investment to promote exporting. However, all of these papers kept silent about the behavioural responses of the firm (in terms of export investment) under external shocks.

The contribution of the present study is precisely to fill in this research gap: analysing the decision problem of such risk-averse domestic exporting firm of a developing country[1] regarding how much investment to be optimally made for exports to the international markets under multiple sources of risk. As recognised in Handley and Limão (2015), this question is extremely novel and has remained to be tackled in the context of a developing country. The primary source of uncertainty is the revenue risk, arising from the fluctuations in the (nominal/spot) exchange rate, as the randomness associated with exchange rate volatility affects both the decision to and the intensity of export.

This study is motivated not only from the class of theoretical literature that models the role of domestic financial institutions and investment on the comparative advantage and pattern of trade (such as Beck, 2003; Carlin and Mayer, 2003; Ju and Wei, 2005; 2011), but also from the papers that explored production and export decisions of exporting firms under exchange rate uncertainty using the standard EU representation (such as Kawai and Zilcha, 1986; Viaene and Zilcha, 1998; Broll and Eckwert, 1999; 2009) or employing the mean-variance modelling approach (Broll and Mukherjee, 2017; Broll et al., 2019).

However, other than the exchange rate risks, the exporting firms also face exogenous factors beyond firm's control (such as variations in firm size, age, changes in the industry-specific uncertain domestic and foreign policies etc.). These factors influence the fixed costs of entering the export market, thereby aiding to the uncertainty surrounding the exporting prospects. In this context, one can see Topalova and Khandelwal (2011) and the references therein, substantiating the importance of firm size and age (in its non-linear form) (measured as a proxy for experience) in determining the firm's decision to export. Moreover, these effects remain independent to that of exchange rate risk. This additional source of uncertainty can be categorised as a background risk, entering passively in the exporter's profit

[1] We have taken the sample of Indian manufacturing firms as a case study to empirically demonstrate the validity of our analytical results/propositions. In this context, Figure 4.2 shows that these firms tend to keep positive risk premium, once they extract positive profits from their export markets.

function (see, Eichner and Wagener, 2009; Franke et al., 2011; Wong, 2012; 2017; Broll and Wong, 2013).

We are incorporating presence of such background risk along with the 'endogenous exchange rate risk' in the context of the export investment decision problem in a mean-variance model, perhaps for the first time (to the best of our knowledge), in the literature of risk management in international trade. The edge of using a mean–variance approach rests on its trouble-free interpretation. Its effects can be instantiated in terms of risk and returns. Moreover, irrespective of the multidimensional risks or choice variables, such model continues to be two dimensional. This approach facilitates direct modelling of such decision problem without assuming anything pertaining to the higher-order and cross-derivatives of the preference functional.

It is worth to mention that the mean-variance (or, equivalently known as 'two-moment') modelling approach sometime is misinterpreted as the particular case of the standard von Neumann – Morgenstern expected utility (EU) representation, which is generally used to model a decision maker's attitude towards risks. But, the mean-variance approach is novel, one of its kind yet delivers analytical simplicity with richer intuitions. To this extent, we need to make the following two standard assumptions. Firstly, all feasible distributions of any random variable differ only with respect to the location and the scale parameters. Secondly, all sources of uncertainty must interact linearly with the decision variable (see Meyer, 1987; for the validity of this assumption). As a result, all other moments of the distributions, except mean and variance, are irrelevant in our context.

After that this paper has also offered an empirical demonstration of how to estimate the risk preference structure of such exporting firms and the risk aversion elasticities. For this purpose, we follow the route (e.g., Saha et al. 1994; Saha 1997; Serra et al. 2006; Cohen and Einev 2007) of directly estimating a flexible utility function in a nonlinear mean-variance framework that nests all possible risk preference structures.

Talking about the sample, we utilise a panel of 840 Indian manufacturing exporters (firms) during the period of 1995-2017. Following Dai & Chang (2018), we employ two-step ACF (Ackerberg et al., 2015) corrected LP (Levinsohn & Petrin, 2003) procedure to estimate firm-level mark-ups. Given the support of recent literature (Mallick and Marques, 2016a; b) that the changes in the export intensity of the firms due to the exchange rate volatility in the international market can be summarised by the mark–up adjustments, we use these mark-ups, as a proxy for firms' risk-premium, to estimate a fixed-effects regression model. Since the mark-up adjustment is also affected by the different firm-specific characteristics (such as cost advantages, market transparency etc.), we have not only incorporated the firm-level controls (such as firm-size and firm-age), but also the firm, year and industry-year fixed effects (to control for the background risk). After that we also extend our fixed effect analysis further to control for potential endogeneity on firm-level mark-ups due to possible sample selection bias in keeping those firms' in the dataset whose export earnings are positive. Thus, we use Heckman's 2-step estimation procedure to control for possible mark-up endogeneity.[2] The findings suggest that the risk preferences of the Indian manufacturing exporters are characterised by decreasing absolute risk aversion and 'variance vulnerability' (in other words, 'proper' risk aversion: see Lajeri-Chaherli, 2002; Pratt and Zeckhauser, 1987). These findings are extremely significant in the relevant domain, given that Broll et al. (2019) has remained the only contribution so far that has attempted to jointly estimate risk preference structure and risk aversion elasticity in the context of the non-financial service sector firms' relative willingness for exporting (relative to domestic sales) at the intensive margin.

The paper is organised as follows. Section 2 discusses the modelling framework in details. Section 3 not only evaluates the optimal investment decision (i) owing to the changes in exchange rate risk distribution, and (ii) due to the perturbation in the distribution of the independent background risk; but also presents the equivalence of

[2] The result remains robust for Heckman's estimation procedure as well.

our comparative static results obtained under mean-variance decision model with the EU approach and the implications of our results in the light of other measures of risk, namely prudence and temperance. Our empirical demonstration is carried out in section 4. Within section 4, the sub-section 4.1 describes the data and estimates firm-level mark-up while the sub-section 4.2 gives the estimation strategy and analysis of the results based on Indian manufacturing exporting firms over 1995-2017 period. Finally, section 5 concludes.

2. The Model

Our investigation rests on the following set of assumptions: We consider an entrepreneur who invests I on a domestic exporting firm to cover the fixed overhead costs for its export production. We assume that the relationship between the invested capital (I) and export production (Q) follows (approximately) a linear production technology: $Q = A.I$, with $A > 0$.[3] The firm's revenues from exports in foreign currency are pQ, with a given world price in p (owing to small open economy assumption). Therefore, the revenue in domestic currency becomes $epQ = ep(AI)$, where the nominal/spot exchange rate e is defined in terms of domestic currency per unit of foreign currency. However, we assume that the spot exchange rate is uncertain at the beginning of the time-horizon, i.e. at $t = 0$, when the investment decision is made. Hence, let us denote the ex-ante revenue in domestic currency as $A\tilde{e}pI$, where $\tilde{e}$ is the random spot exchange rate, which is distributed according to a given cumulative distribution function (CDF), over support $[\underline{e}, \bar{e}]$.[4] Assuming rental

[3] One can always assume any constant returns to scale (CRS) production technology for a firm using two broad inputs: a bundle of labour and intermediate goods (L) and invested capital (I). Now, it can be easily checked that any CRS production technology, viz., Cobb-Douglas, constant elasticity of substitution or trans-log production function would yield the linear relationship between Q and I for a given level of L-I ratio (say the steady-state level). We can also assume that the firm faces a pre-specified interest rate schedule, $r(I)$, with $r'(.) > 0$, $r''(.) > 0$. However, for analytical simplicity, we assume that the cost of investment is linear, viz., rI.

[4] All random variables are denoted by a tilde, while their realisations are not.

return of capital as r in the domestic country, the rental cost of investment in the home country is rI.

There is an independent background risk ($\tilde{Z}$). If the firm is larger and matured enough, while the firm is also blessed with an overall stable management policy, then $\tilde{Z} \rightarrow Z^*$ (Z^* can be thought of certain fixed costs of operations for matured firm). Otherwise, $\tilde{Z}$ is random and aiding to the uncertainty in firm's net profit from exports "passively". We measure $\tilde{Z}$ in domestic country's currency and characterise it as a "passive" random variable entering the firm's net profit (from exports) function additively.

$$\tilde{\pi} = A\tilde{e}pI - rI - \beta\tilde{Z} \tag{2.1}$$

where $\beta > 0$ can be used to introduce ($\beta = 0$ initially) or change background risk.

For any random variable $\widetilde{W}$, the mean and variance are denoted by respectively, μ_W and v_W. The variance and mean of final profit can then be written respectively as

$$v_\pi = v_e(ApI)^2 + \beta^2 v_Z \tag{2.2}$$

$$\mu_\pi = \mu_e ApI - rI - \beta\mu_Z = \mu_{\pi_e} - \beta\mu_Z \tag{2.3}$$

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 preference of the exporter satisfies non-satiation, and that the exporter is risk-averse[5], wherein the indifference curves in (μ_π, v_π)-space are upward-sloped. Given that all random variable(s) ($\tilde{e}$ and/or $\tilde{Z}$) is/are interacting linearly with the decision variable (I^*), all other moments of the distributions, except mean and variance, are irrelevant in our context.[6] The marginal rate of substitution (MRS) between v_π and μ_π is defined by

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

[5] Recent empirical evidence (see, for example, Nakhoda, 2018) found that 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 exporters are generally risk-averse.

[6] Please see Broll et al. (2006); Broll & Mukherjee (2017); Broll et al. (2019) as only few of the many relevant contributions who have also justified the validity of this assumption in the context of exchange rate risk.

where $S > 0$ is the marginal willingness to pay (in terms of expected profit foregone renouncing to invest for exporting) for a reduction in the variance of the net final profit, or the "marginal rate of substitution" (MRS) between risk and return (see Broll and Mukherjee, 2017; Broll et al., 2019). The positivity of the MRS indicates upward sloping indifference curves in (v, μ)-space, with their slopes exhibiting risk aversion. It is also a two-parameter analogue to the Arrow–Pratt measure of absolute risk aversion (see Eichner and Wagener, 2012; and the references therein).

The firm solves the following problem:

$$\max_{(I \geq 0)} U(\mu_\pi, v_\pi) \text{ s.t. } (2.2) \;\&\; (2.3) \tag{2.4}$$

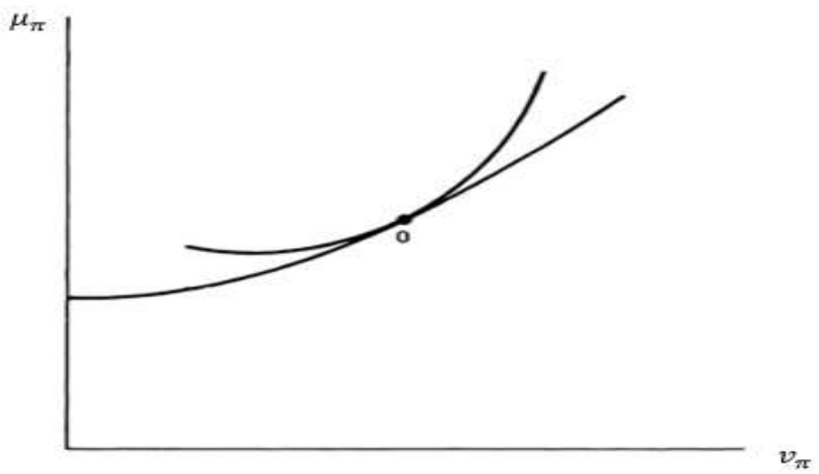
The necessary condition for an interior solution to the firm's maximization problem is

$$\frac{(\mu_e Ap - r)}{\left(\frac{\partial v_\pi}{\partial I}\right)} = S(\mu_\pi(I^*), v_\pi(I^*)) \tag{2.5}$$

where $(\partial v_\pi / \partial I) = 2 v_e I (Ap)^2$.

F.O.C. in Eq. 2.5 then defines the marginal condition where the slope of a (v_π, μ_π) – indifference curve (denoted by the LHS) or the marginal willingness to pay, in terms of expected returns foregone, owing to reducing the investment for exporting is equal to the slope of the so-called "efficiency frontier" (i.e. at point 0 of the diagram below).

Figure 2.1: Efficiency Frontier



Note that the numerator in the LHS of Eq. 2.5, $(\mu_e Ap - r)$, is nothing but the risk premium of the domestic entrepreneur for the risky activity of investing for exporting activity.

If the exporting firm is risk-averse, risk-premium is positive. As we will show in Figure 4.2, our sample of Indian manufacturing firms, as they extract positive profits from exporting, are inclined to improve upon their risk premium to significantly higher values. Therefore, with this presumption of modelling the preferences of risk averse firms, Eq. 2.5 suggests $(\partial v_\pi / \partial I) > 0$, implying investing on exporting activity is always risky: higher investment increases profit-risk at the margin.

Before proceeding to the comparative static exercises, we are defining a few concepts below.

Definition 1. The elasticity of the relative willingness-to-pay for a reduction in profit risk with respect to the variance of the random final profit is

$$\varepsilon_v(\mu_\pi, v_\pi) = \frac{\partial S(\mu_\pi, v_\pi)}{\partial v_\pi} \frac{v_\pi}{S(\mu_\pi, v_\pi)}.$$

The elasticity $\varepsilon_v(\mu_\pi, v_\pi)$ represents the proportional change in MRS over the proportional change in profit-risk, keeping the mean μ constant.

Definition 2. We define the elasticity of the relative willingness-to-pay for a reduction in risk with respect to the expected profit,

$$\varepsilon_\mu(\mu_\pi, v_\pi) = \frac{\partial S(\mu_\pi, v_\pi)}{\partial \mu} \frac{\mu}{S(\mu_\pi, v_\pi)},$$

i.e. elasticity $\varepsilon_\mu(\mu_\pi, v_\pi)$ represents the proportion change in MRS over the proportional change in expected final profit, keeping the variance constant.

With these definitions in hand, let us begin with the first set of comparative static exercises, i.e. decision to optimally invest on trade with respect to the changes in the distribution of the nominal exchange rate.

3. Comparative static responses: changes in the distribution of nominal exchange rate

In this section, we are interested in how optimal investment decision of the firm responds to the changes in the world market.

Proposition 1. Higher exchange rate volatility v_e leads to a decrease in optimum investment I^* if and only if $\varepsilon_v(I^*) > -1$, (b) An increase in the expected exchange rate μ_e will lead to an increase in optimum investment I^* if and only if $\varepsilon_\mu(I^*) < 1$.

Proof.

(a) Applying implicit function theorem, we obtain,

$$\text{sgn}\left(\frac{\partial I^*}{\partial v_e}\right) = \text{sgn}\left[S(\mu_\pi(I^*), v_\pi(I^*))\frac{\partial^2 v_\pi(I^*)}{\partial I \partial v_e} + \frac{\partial v_\pi(I^*)}{\partial I}\frac{\partial S}{\partial v_\pi}\frac{\partial v_\pi}{\partial v_e}\right] \qquad (3.1)$$

Where

$$\frac{\partial^2 v_\pi(I^*)}{\partial I \partial v_e} = 2I^*(Ap)^2 = (\partial v_\pi/\partial I)(1/v_e)$$

$$\frac{\partial v_\pi}{\partial v_e} = (ApI^*)^2 = v_\pi(I^*)/v_e - \beta^2(v_Z/v_e)$$

$$\left(\frac{\partial v_\pi(I^*)}{\partial I}\right).\left(\frac{I^*}{v_\pi}\right) = \frac{2v_e(ApI^*)^2}{v_\pi} = 2\left[1 - \beta\frac{\beta v_Z}{v_\pi}\right].$$

Or,

$$\frac{1}{2}\left(\frac{\partial v_\pi(I^*)}{\partial I}\right).\left(\frac{I^*}{v_\pi}\right) \in (0,1).$$

Therefore,

$$\text{sgn}\left(\frac{\partial I^*}{\partial v_e}\right) = \text{sgn}\left[S\big(\mu_\pi(I^*), v_\pi(I^*)\big)(\partial v_\pi/\partial I)(1/v_e) + \frac{\partial v_\pi(I^*)}{\partial I}\frac{\partial S}{\partial v_\pi}\left\{v_\pi(I^*)/v_e - \beta^2\left(\frac{v_Z}{v_e}\right)\right\}\right]$$

$$= S.\text{sgn}\left[(\partial v_\pi/\partial I)(1/v_e) + \frac{\partial v_\pi(I^*)}{\partial I.v_e}\frac{\partial S}{\partial v_\pi}\frac{v_\pi(I^*)}{S(I^*)} - \frac{\partial v_\pi(I^*)}{\partial I.v_e}\frac{\partial S}{S.\partial v_\pi}\beta^2 v_Z\right]$$

$$= (\partial v_\pi/\partial I)(1/v_e).S.\text{sgn}\left(\frac{\varepsilon_v\left(\frac{\partial v_\pi(I^*)}{\partial I}\right).\left(\frac{I^*}{v_\pi}\right)}{2} + 1\right) \qquad (3.2)$$

From Eq. 3.2 we obtain, $\left(\frac{\partial I^*}{\partial v_e}\right) \leq 0$, if and only if

$$\varepsilon_v(I^*) \leq -2/\left(\frac{\partial v_\pi(I^*)}{\partial I}\right).\left(\frac{I^*}{v_\pi}\right) \tag{3.3}$$

Since, $\frac{1}{2}\left(\frac{\partial v_\pi(I^*)}{\partial I}\right).\left(\frac{I^*}{v_\pi}\right) \in (0,1)$, it can easily be deduced that the above inequality is satisfied if and only if $\varepsilon_v(I^*) > -1$. (Q.E.D.)

A small rise in v_e results in lower revelation to the exchange rate risk (and, thus, to a lower μ_π), provided the slope of the indifference curve (which, at the optimum, is locally proportional to S_v) becomes more sensitive to an increase in v_e than the slope of the efficiency frontier (which is locally proportional to the value of risk aversion, S). In other words, the degree of risk aversion must not significantly worsen with increase in riskiness in the external macro-environment.

In other words, increase in v_e leads to a "substitution effect" (less export, and consequently, less investment owing to higher risk), and an "income (wealth) effect" (greater variability in export prices is also associated with a possibility of higher return in terms of expected profitability).[7] The sufficiency condition $\varepsilon_v(I^*) > -1$ ensures that the substitution effect remains relatively stronger than this wealth effect, resulting less investment on exports owing to a small rise in v_e.

(b) Similarly, implicit differentiation of the F.O.C. in Eq. 2.5 yields

$$\text{sgn}\left(\frac{\partial I^*}{\partial \mu_e}\right) = \text{sgn}\left[1 - \frac{\partial v_\pi(I^*)}{\partial I}\frac{\partial S}{\partial \mu_\pi}\frac{\partial \mu_\pi}{\partial \mu_e}\right]$$

$$= (Ap).\,\text{sgn}\left[1 - \frac{\mu_\pi(I^*)}{S(I^*)}\frac{\partial S}{\partial \mu_\pi}\right] = (Ap).\,\text{sgn}\left[1 - \varepsilon_\mu\right]$$

(3.4)

Therefore, we have $\left(\frac{\partial I^*}{\partial \mu_e}\right) \geq 0$, under the sufficiency condition $\varepsilon_\mu \leq 1$. (Q.E.D.)

[7] See Davis (1989); Broll et al. (2015); Broll and Mukherjee (2017) in this context.

Increasing μ_e will lead to greater intention to participate in the export market, implying a higher overall risk, v_π, provided the consequential change in the slope of the indifference curve (which is proportional to $\frac{\partial S}{\partial \mu_\pi}$) is smaller than the subsequent change in the slope of the efficiency frontier (locally proportional to S).

Higher μ_e implies more exposure to the macroeconomic uncertainty by opting for more exports, pushing the decision-maker towards investing less on exports ("substitution effect"). However, given that μ_π also increases, it also entails the possibility of higher expected return ("income effect"). $\varepsilon_\mu \leq 1$ ensures that the "income effect" stands relatively stronger.

The next sub-section traces out the impact of the perturbation in the distribution of the background risk.

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

Proposition 2.

a) *A risk-averse firm will optimally export more (less) under lower (higher) expected value of $\tilde{Z}$ if and only if the preference are DARA.*

b) *A risk-averse exporting firm may optimally export less under higher background risk if and only if its preference is 'variance vulnerable'.*

Proof.

(a) Implicit differentiation of Eq. 2.5 with respect to (w.r.t. hereafter) μ_Z, we obtain

$$\operatorname{sgn}\left(\frac{\partial I^*}{\partial \mu_Z}\right) = \operatorname{sgn}\left[-S_\mu \frac{\partial \mu_\pi^*}{\partial \mu_Z}\right] = \beta \operatorname{sgn} S_\mu(\mu_\pi^*, v_\pi^*) \tag{3.5}$$

(b) Similarly, totally differentiating Eq. 2.5 w.r.t. v_Z, we obtain

$$\operatorname{sgn}\left(\frac{\partial I^*}{\partial v_Z}\right) = \operatorname{sgn}\left[-S_v \frac{\partial v_\pi^*}{\partial v_Z}\right] = -\beta^2 \operatorname{sgn} S_v(\mu_\pi^*, v_\pi^*) \tag{3.6}$$

Therefore, as μ_Z increases, the risk-averse firm opts for optimally investing less (i.e. $\frac{\partial I^*}{\partial \mu_Z} < 0$) in order to ameliorate the possible loss, if and only if $S_\mu < 0$, which directs to the DARA ("decreasing absolute risk aversion") preference structure, which means firm's marginal willingness to pay in terms of expected returns foregone by reducing investment for exports for a reduction in v_π decreases in expected profit.

On the other hand, $\frac{\partial I^*}{\partial v_Z} < 0$, if and only if $S_v > 0$, which establishes the "variance vulnerability" property of the preferences. This implies that the optimum investment would even be lesser when the higher background risk aids to the overall riskiness of exporting. Hence, higher volatility of $\tilde{Z}$ makes the firm to invest relatively less for exporting if its willingness to accept risks intensifies when the profit-risk is escalated. One can see Eichner and Wagener (2003; 2009; 2012) in this context.

The next sub-section discusses the equivalence with the EU approach and the implications of our results in the light of other measures of risk, namely prudence and temperance.

3.2 Equivalence between the Mean-Variance and vNM Expected Utility Approaches, with the Notions of Prudence and Temperance[8]

We have already mentioned that the nature of our very problem, i.e. linear interactions of all random variable(s) ($\tilde{e}$,$\tilde{Z}$,$\tilde{\pi}$) with the decision variable (I^*), corresponds to the conformity of the location-scale conditions, so that all viable distributions vary only by location and scale parameters. We examine a choice set Y, where random variables $y \in Y$ differ only in terms of location and scale parameters. We consider x as the random variable obtained by normalization of an arbitrary $y \in Y$. Then all $y \in Y$, is symmetrical in distribution to $\mu_y + \sqrt{v_y}x$, where μ_y and v_y are the mean and the variance respectively. Given a von-Neumann Morgenstern (vNM) utility index $w: \mathbb{R} \to \mathbb{R}$, one can write the expected utility emanating from the distribution of y using the mean and the variance of y:

[8] We are grateful to an anonymous referee for his/her suggestion to include this section.

$$Ew(y) = \int_a^b w\left(\mu_y + \sqrt{v_y}x\right)dF(x) \equiv U\left(\mu_y, v_y\right) \tag{3.7}$$

Identity (3.7) recommends structural relationships between functions w and U. We utilise these relationships to demonstrate the comparative static results obtained in this paper have well-known correspondences in the EU framework.

The utility function $w(.)$ is three times continuously differentiable with $w'(y) > 0 > w''(y)\forall y$, implying that the firm is risk-averse (which is consistent with our sample of Indian manufacturing exporters, see Figure 4.2 in this context). As shown in Meyer (1987); Eichner & Wagener (2004; 2009)

$$w'(y) > 0\forall y \Leftrightarrow U_\mu\left(\mu_y, v_y\right) > 0\forall\left(\mu_y, v_y\right)$$

$$w''(y) < 0\forall y \Leftrightarrow U_v\left(\mu_y, v_y\right) < 0\forall\left(\mu_y, v_y\right)$$

$$\Leftrightarrow U_{\mu\mu}\left(\mu_y, v_y\right) < 0\forall\left(\mu_y, v_y\right)$$

$$w'''(y) > 0\forall y \Leftrightarrow U_{\mu v}\left(\mu_y, v_y\right) > 0\forall\left(\mu_y, v_y\right)$$

Meyer (1987) shows that $S_\mu < 0$ (or, equivalently, $\varepsilon_\mu < 1$) indeed is the mean–variance analogue to the EU concept of DARA (i.e., to $-w''(y)/w'(y)$ decreasing in y). In other words, both propositions 1(b) and 2(a) hinge on the sufficiency condition of DARA. Lajeri-Chaherli (2004) and Eichner & Wagener (2004; 2009; 2012) showed that $\varphi = -y[w'''(y)/w''(y)] = -U_{\mu v}/U_{\mu\mu}$ is the ***index of relative absolute prudence***. Given this, Wagener (2002) explicitly demonstrated that since $S_\mu = -\left[U_\mu U_{v\mu} - U_{\mu\mu}U_v\right]/U_\mu^2$; $S_\mu < 0$ (equivalently, $\varepsilon_\mu < 1$) implies $\varphi\left(\mu_y, v_y\right) > S\left(\mu_y, v_y\right)$.

The measure φ also offers a straightforward adaptation of Kimball's (1990) notion of ***decreasing absolute prudence (DAP)***. As demonstrated by Lajeri & Nielsen (2000) and Wagener (2002), the equivalent to DAP in the mean-variance framework is that φ decreases in μ.

Now, following Eichner & Wagener (2004); in the absence of any background uncertainty ($\tilde{Z} = 0$), the F.O.C. in (2.5) can be expressed in terms of the following function

$$\Omega(\mu_\pi^*, v_\pi^*) = (I^*/2)(\mu_e Ap - r)U_\mu(\mu_\pi^*, v_\pi^*) + v_e(ApI^*)^2 U_v(\mu_\pi^*, v_\pi^*)$$
$$= (1/2)\mu_\pi^* U_\mu(\mu_\pi^*, v_\pi^*) + v_\pi^* U_v(\mu_\pi^*, v_\pi^*) = 0$$

It can easily be shown that $\Omega(\mu_\pi^*, v_\pi^*)$ is decreasing in v_π (see Eichner & Wagener, 2004, p. 164 (Proof for Proposition 1(b)) if and only if index of relative prudence φ is less than 2.

Gollier & Pratt (1996); Eeckhoudt et al. (1996) defined $T(z) := -u''''(z)/u'''(z)$ as the coefficient of temperance. Wagener (2002) defined a mean-variance measure for temperance:

$$\tau(\mu_y, v_y) := -U_{v\mu\mu}(\mu_y, v_y)/U_{\mu\mu\mu}(\mu_y, v_y)$$

Propositions 1(a) and 2(b) rest on the condition of "variance vulnerability" property, owing to which $S_v > 0$ and $\varepsilon_v > -1$. Kimball (1993); Eeckhoudt et al. (1996); Gollier & Pratt (1996); Eichner & Wagener (2003) suggest that this property is derived from the following properties of the EU approach:

(i) ***The absolute temperance index is greater than the index of absolute risk aversion*** (known as "local risk vulnerability" property).

(ii) Adding an additional (exogenous) risk makes an initial, undesirable (or desirable) background risk even more undesirable (less desirable), also known as "standard risk aversion. In the context of EU framework either of these above-mentioned properties implies when a decision maker confronts an independent zero-mean background risk, s/he reduces the optimal risk taking.

4. Empirical Framework

In this section we attempt an empirical demonstration of how to estimate the risk preference structure of such exporting firms and the risk aversion elasticities. Using a large sample of Indian manufacturing firms, we demonstrate how to jointly estimate risk preference structure and risk aversion elasticities for a panel of 840 exporting firms over 1995-2017 period. For this purpose, we use following route (e.g., Saha et al. 1994; Saha 1997; Serra et al. 2006; Cohen and Einev 2007) of directly estimating a flexible utility function in a nonlinear mean – variance framework that nests all possible risk preference structures:

Let us start with by considering the flexible preference structure, as in Saha (1997); Broll & Mukherjee (2017).

$$U(\mu_\pi, v_\pi) = \mu_\pi^a - v_\pi^b \tag{4.1}$$

Where,

$\mu_{\pi_{it}}$ is expected relative net profit of a firm. To measure it, we follow Schmidt and Broll (2009) who estimated expected future change in a variable as the ratio of the predicted value to the actual value, where predicted value is calculated from a time regression. Accordingly, we measure $\mu_{\pi_{it}}$ as the ratio of the predicted net profit of each firm to the actual net profit, where the predicted net profit is arrived at by regressing average net profit on a time trend.

$v_{\pi_{it}}$ is measured as the square of the mean deviation of the net export profit from the actual net profit.

$(\partial v_\pi(I^*)/\partial I)$ =change in squared mean deviation of net profits due to change in domestic investments in raw materials

From the F.O.C. in Eq. (2.5) of the theoretical model, we obtain,

$$\frac{\text{Risk premium}}{(\partial v_\pi(I^*)/\partial I)} = S\big(\mu_\pi(I^*), v_\pi(I^*)\big) = -\frac{U_v}{U_\mu} = \frac{b}{a}\mu_\pi(I^*)^{1-a} v_\pi(I^*)^{b-1}$$

Or,

$$\ln(\text{Risk premium}) = \ln\left(\frac{b}{a}\right) + (1-a)\ln\mu_\pi + (b-1)\ln v_\pi + \ln(\partial v_\pi(I^*)/\partial I) \tag{4.2}$$

Since all the variables measuring risk distribution $\left(\mu_\pi, v_\pi, (\partial v_\pi(I^*)/\partial I)\right)$, including the export sales, are expressed in INR, and given that we have deflated all these variables by the industry-specific wholesale price indices (keeping 2004 as the base year), proportional changes in these variables do subsume the proportional changes in the distribution of nominal/spot exchange rate, defined as INR per unit of foreign currency. Moreover, from Eq. 2.5, we can easily see that $(\partial v_\pi(I^*)/\partial I) = f(v_e), f'(.) > 0$. Hence, we do not need to include additional mean and variance of spot exchange rate distribution to the RHS of Eq. 4.2.

Therefore, we obtain from the model that elasticity of the MRS with respect to v is: $\varepsilon_v = (b-1)$; while the elasticity of the MRS with respect to μ_π is: $\varepsilon_\mu = (1-a)$. Proposition 1(a) states that higher exchange rate volatility leads to a decrease in optimum investment if and only if $\varepsilon_v > -1$ or $(b-1) > -1$. Proposition 1(b) implies an increase in the expected exchange rate will lead to an increase in optimum investment if and only if $\varepsilon_\mu < 1$, or $(1-a) < 1$. However, if $(1-a) < 0$, the corresponding firm(s) is(are) characterised by DARA, while if $(1-a) > 0$, the corresponding firm(s) is(are) characterised by increasing absolute risk aversion (IARA); and if $a = 1$, the corresponding firm(s) is(are) characterised by constant absolute risk aversion (CARA).

Propositions 2(a) and 2(b) stand on the sufficiency conditions of DARA and "variance vulnerability" respectively. Since,

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

Therefore, DARA or $S_\mu < 0$ implies $(1-a) < 0$. Similarly, as

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

"Variance vulnerability" implies $b > 1$. Hence, we need to examine whether the coefficient estimates of $\ln v_\pi$ is positive (and statistically significant) or not and simultaneously, the coefficient estimate of $\ln \mu_\pi$ is negative (and statistically significant) or not.

Given the definition of the risk-premium, we can proxy this risk-premium by the firm-level mark-up that we estimate using the Dai and Cheng (2018)'s approach for 840 Indian manufacturing exporting firms (See, Sub-Section 4.1). To quantitatively examine these predictions, we use (4.2) as our unique structurally estimable equation.

4.1 Measuring firm-level Markup

We estimate firm-level markup following the approach used by Dai and Cheng (2018) while estimating the latter for Chinese manufacturing firms. The estimation of firm-level markup is summarized in the following steps:

Step 1: At first, we estimate output elasticities by assuming a flexible translog production function with Hicks-neutral productivity, highlighted in equation (4.3):

$$q_{it} = \beta_m m_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_p p_{it} + \beta_{mm} {m_{it}}^2 + \beta_{kk} {k_{it}}^2 + \beta_{ll} {l_{it}}^2 + \beta_{pp} {p_{it}}^2 + \beta_{mk} m_{it} k_{it} + \beta_{ml} m_{it} l_{it} + \beta_{mp} m_{it} p_{it} + \beta_{mkl} m_{it} k_{it} l_{it} + \beta_{mkp} m_{it} k_{it} p_{it} + \beta_{mlp} m_{it} l_{it} p_{it} + \omega_{it} + \epsilon_{it} \tag{4.3}$$

where lower case represents logarithm of the uppercase variables (Q_{it}, M_{it}, K_{it}, L_{it} and P_{it}, which denote sales revenue, raw materials expenses, capital expenses, labour expenses and power and fuel expenses, respectively. Firm productivity is denoted as ω_{it} while ϵ_{it} is the error term.[9]

[9] We use deflated sales revenue, capital spending and different input expenditures as proxies for the physical quantities of output, capital and intermediate inputs, respectively, following the literature on productivity estimation. To get the deflated values of sales, compensation to employees, power and fuel expenditure,

Using Ackerberg, Caves, and Frazer (2015)'s two-step estimation procedure which is a modified control function approach of Levinsohn and Petrin (2003), we consistently estimate the output elasticities and finally Revenue Productivity (ω_{it}) after controlling the simultaneity problem in choosing labour, capital[10] and other factor inputs based on their current productivity levels.

Table 4.1: LP (ACF Corrected) Translog Production Function Estimation for Indian Manufacturing Firms

VARIABLES	(1) All Firms
ln_Deflated_Compensation	0.3501469***
	(0.0077988)
ln_Deflated_Power_Fuel	0.1798385***
	(0.0031006)
ln_Deflated_Capital_Employed	0.0687381***
	(0.0033789)
ln_Deflated_RM_Expences	0.3690546***
	(0.0051218)
ln_Deflated_Compensation²	0.0342828***
	(0.007444)
ln_Deflated_Compensation * ln_Deflated_Power_Fuel	-0.013659***
	(0.0030434)
ln_Deflated_Compensation * ln_Deflated_Capital_Employed	0.0180044***
	(0.0051267)
ln_Deflated_Compensation * ln_Deflated_RM_Expences	-0.0789584***
	(0.0056066)
ln_Deflated_Power_Fuel²	0.0188136***
	(0.0050963)
ln_Deflated_Power_Fuel * ln_Deflated_Capital_Employed	-0.0111663***
	(0.0025436)
ln_Deflated_Power_Fuel * ln_Deflated_RM_Expences	-0.0231569***
	(0.0039149)
ln_Deflated_Capital_Employed²	0.0081677**

capital employed, raw material expenditure, we use industry- specific wholesale price indices, keeping 2004 as the base year to accord with the 1995-2017 period covered by our study. All the industry specific-wholesale price indices are obtained from the Economic Adviser, Ministry of Commerce and Industry, Government of India. http://www.eaindustry.nic.in/wpi_revision_0405.asp

[10] To estimate the firm-level physical capital stocks for each year we closely follow the methodology adopted by P. Balakrishnan et al. (2006), which uses perpetual inventory model. At first, we obtain firm-level net investment by taking the difference between the current and lagged values of gross assets less depreciation for each year. Next, by taking the sum of investment in subsequent years for each firm, we obtain the firm-level capital stock for every time period. Moreover, using industry- specific wholesale price indices of Machinery and machine tools and keeping 2004 as the base year to accord with the 1995-2017 period, we obtain firm-level real capital stock for each year by deflating the value of capital stock obtained in the previous step. For more detail of this method see, P. Balakrishnan et al. (2006) (pp.71-73), and Topalova and Khandelwal (2011) (pp. 23).

	(0.0041634)
ln_Deflated_Capital_Employed * ln_Deflated_RM_Expences	-0.026733***
	(0.0026846)
ln_Deflated_RM_Expences²	0.0591367***
	(0.0037788)
Observations	46,429
Number of groups	6,635

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Step 2: Once we get the estimates for firm-level output elasticities with respect to various inputs used in our translog production function, in the last step, following De Loecker and Warzynski (2012)'s approach, we can recover firm-level markup (φ_{it}) using equation 4.4,

$$\varphi_{it} = \frac{\theta_{it}^{M}}{\alpha_{it}^{M}} \tag{4.4}$$

where θ_{it}^{M} denotes the output elasticity with respect to intermediate materials and α_{it}^{M} denotes the share of expenditures on intermediate material inputs in total sales revenue. While α_{it}^{M} can be directly calculated using the indictors in our data, θ_{it}^{M} can only be obtained by estimating the production function. Equation 4.5 provides an illustration of the estimation of firm-level output elasticity with respect to material input expenses for all firms, which uses the estimated coefficients of Column 1 in Table 4.1:

$$Output\_Elasticity\_RM_{it} = 0.3690546 + 2 * 0.0591367 * ln\_RM\_Expences_{it} - 0.026733 * ln\_Capital_{it} - 0.0789584 * ln\_Compensation_{it} - 0.0231569 * ln\_Power\_Fuel_{it} + 0.0180044 * ln\_Compensation_{it} * ln\_Capital_{it} - 0.013659 * ln\_Compensation_{it} * ln\_Power\_Fuel_{it} - 0.0111663 * ln\_Power\_Fuel_{it} * ln\_Capital_{it} \tag{4.5}$$

Figure 4.2 gives the distribution of firm-level mark-ups for all manufacturing firms and profit-making exporting firms.

Figure 4.2: Histogram of Firm-level Log (Mark-up) for All Manufacturing Firms and Profit-Making Exporting Firms

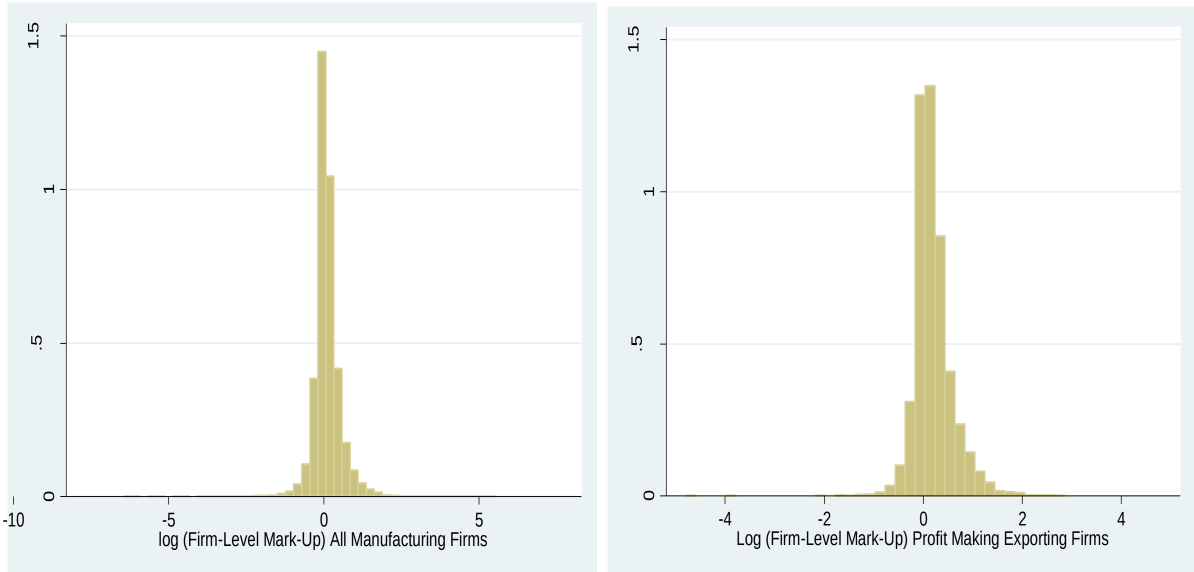


Figure 4.2 clearly highlights a positively skewed distribution of firm-level mark-ups for profit-making exporting units (i.e., for those firms whose net export earnings to domestic raw materials expenses are positive), compared to that for all manufacturing firms. This gives an indication of firm's tendency of keeping positive and relatively higher risk premium, if firm extracts positive profits from its export markets.

4.2 The Estimation Strategy and Analysis

In this section we empirically test equation 4.2, where our main objective is to examine the independent effects of firm-level mean (to infer on the changes in $\mu_{\pi_{it}}$), squared mean deviation of net profit from export market (in order to infer on the changes in $v_{\pi_{it}}$) and most importantly change in the squared mean deviation of net profits (from exports) due to change in domestic investments in raw materials (in order to infer on the changes in $\ln(\partial v_{\pi}(I^{*})/\partial I)$) on firm-level mark-up (which measures risk premium) for Indian exporting firms over the study period. We use an unbalanced panel dataset of around 840 Indian exporting firms operating over the 1995 to 2017 period. We use fixed effect approach to determine the independent effects of all these aforementioned firm-level variables (i.e., the firm-level performance and risk indicators in the export markets) on firm-level mark-up, while taking into account other unobserved firm, year, industry level heterogeneity, as presented in Table 4.2. Besides, in our fixed effect models on mark-up, we control with firm age, age square, firm size (total asset used as proxy variable) which contribute directly to the firm-level background risk, apart from the main variables of interest (i.e., risk and return of exports)[11].

Column 1 of Table 4.2 represents the estimation results of the risk aversion elasticities with respect to risk (squared mean deviations and change in squared mean deviations) and return (mean), while taking into account other unobserved firm and year fixed effects. In Column 2 we present the results of the updated model where along with the existing variables we also include various firm controls (age, age square and firm size) which contribute to firm's background risk. Finally, in Column

[11] Topalova and Khandelwal (2011) have shown that firm size and age (in its non-linear form) (measured as a proxy for experience) play an important role in determining the firm-level productivity over time. In similar line we also control for firm size, age and age^2 in our model while estimating firm-level Mark-up, which has been derived from firm-level Productivity.

3, we present the results of the final version of our model where we also incorporate industry-year fixed effects to control for any industry level domestic as well as foreign policies during the study period, which can broadly contribute to firm's background risk. It should also be noted that in each of the regressions, the standard errors are clustered at the firm level.

As per our theoretical background, we expect positive risk aversion elasticities with respect to the squared mean deviation (i.e. variance/profit-risk) and change in mean deviation of net export earnings due to change in domestic investments on raw materials. This is because more volatile the export earning value is, higher would be firm's risk premium. While, the risk aversion elasticity with respect to the mean of net export earning is expected to be negative, as firm tends to keep less risk premium on account of higher return from its export market. The coefficients of all variables of interest represented in Table 4.2 remain significant and come with the expected signs. Thus, our theoretical model gets empirically validated. For instance, in our final version of the model with firm, year and industry-year fixed effects (i.e., Column 3), the coefficient of change in mean deviations of net export earnings due to change in domestic investments suggests, if the latter increases by 1 percent the firm-level mark-up increases by 0.008 percent. This highlights that the risk averse firm increases its risk premium by 0.008 percent in an event of a one percent increase in the risk (i.e., volatility) in net export earnings.

On the other hand, the coefficient of mean (i.e., average returns from export markets) suggests a 0.021 percent decline in firm-level mark-ups due to one percent increase in mean returns from export market. This gives a clear evidence of reduction in risk premium (around 0.021 percent) by a risk-averse exporting firm on account of higher average return from the export market. In other words, $(1 - a)$ of Eq. 4.2 is negative, or equivalently, $\varepsilon_\mu < 0$, which leads to the inference that the firms are exhibiting "decreasing absolute risk aversion" or DARA (with $a > 1$).

Similarly, the coefficient of the variance (proxied by the square of the mean deviation) of net profit from export market (which corresponds to ε_σ, which is also equal to $b - 1$ in Eq. 4.2) is positive and less than the unity. Therefore, b is greater than 1 or $S_\sigma > 0$, which implies these firms are "variance vulnerable". On the other hand, since ε_σ is greater than -1, we can also infer $b > 0$, implying risk aversion behaviour of the firms in our sample.

Moreover, the coefficient of total asset (i.e., proxy for firm-size) suggests that a one percent increase in firm size would increase the firm-level mark up by 0.0743 percent. This indicates that a risk-averse exporting firm would able to significantly increase its risk premium if its size increases. Besides, corroborating the existing studies, we find a non-linear relationship between firm age and mark-ups.

Table 4.2: Firm-level Risk Aversion Elasticities with respect to Risk and Returns of Exports for Indian Exporting Firms

	(1)	(2)	(3)

VARIABLES	ln_Markup Exporting Firms	ln_Markup Exporting Firms	ln_Markup Exporting Firms
$\boldsymbol{log\ (\frac{d\,(mean\ deviation\ of\ net\ export\ earning^2)}{d(investments\ in\ domestic\ raw\ materials)})}$	0.00737**	0.00722**	0.00800**
	(0.00306)	(0.00309)	(0.00343)
$\boldsymbol{log(\ mean\ deviation\ of\ net\ export\ earning^2)}$	0.0151***	0.0112**	0.00660
	(0.00466)	(0.00570)	(0.00571)
$\boldsymbol{log(mean\ of\ net\ export\ earning)}$	-0.00884	-0.00854	-0.0210*
	(0.0111)	(0.0113)	(0.0119)
Age		-0.00810**	-0.0124**
		(0.00408)	(0.00546)
Age²		3.18e-05	0.000116**
		(6.06e-05)	(5.62e-05)
Size		0.0413	0.0743**
		(0.0354)	(0.0366)
Constant	0.185***	0.188***	0.227**
	(0.0341)	(0.0585)	(0.114)
Observations	2,611	2,581	2,581
R-squared	0.070	0.076	0.447
Number of firms	851	840	840
Firm Fes	**YES**	**YES**	**YES**
Year Fes	**YES**	**YES**	**YES**
Industry-Year Fes	**NO**	**NO**	**YES**

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Although our above findings remain robust across various specifications (including unobserved firm, year and industry level heterogeneity), we extend our analysis further to control for potential endogeneity on firm-level mark-ups due to possible sample selection bias in keeping those firms' in the dataset whose export earnings are positive. Thus, we use Heckman's 2-step estimation procedure to control for possible mark-up endogeneity.[12] The Heckman's Two-step Model can be explained by the following system of equations which uses all these aforementioned variables:

[12] We have used a novel approach to address the possible endogeneity problem in firm's decision making on firm-level Mark-up (i.e., potential positive mark-up bias), which could arise due to possible sample selection bias in keeping only exporting firms (i.e., export earnings are positive) in our dataset. **(please see, page 160 of James J. Heckman (1979, pp. 153-161) 'Sample Selection Bias as a Specification Error,'** for further details. However, we have also performed the usual **Dynamic Panel System GMM** (**Blundell and Bond, 1998)**

$$log\ markup_{ijt} = \alpha_1 + \beta_1 log\ (\frac{d\ (mean\ deviation\ of\ net\ export\ earning^2)}{d(investments\ in\ domestic\ raw\ materials)})_{ijt}$$
$$+ \beta_2 \log(mean\ deviation\ of\ net\ export\ earning^2)_{ijt}$$
$$+ \beta_3 \log(mean\ of\ net\ export\ earning)_{ijt} + \beta_4 Size_{ijt} + \beta_5 age_{ijt}$$
$$+ \beta_6 age^2{}_{ijt} + C_i + \tau_t + \lambda_{ij} + \varepsilon_{ijt} \quad if\ \rho_{ijt} > 0$$

$$log\ markup_{ijt} = 0\ if\ \ \rho_{ijt} \leq 0 \tag{4.6}$$

Here, $\boldsymbol{\rho_{ijt}}$ is the latent variable (unobserved) variable, which denotes the probability of having positive markup change for the ***firm i from industry j*** in period ***t***. It can be estimated by using following selection equation:

$$\rho_{ijt} = \mu_1 + \pi_1 log\ (\frac{d\ (mean\ deviation\ of\ net\ export\ earning)}{d(investments\ in\ domestic\ raw\ materials)})_{ijt}$$
$$+ \pi_2 \log(mean\ deviation\ of\ net\ export\ earning)_{ijt}$$
$$+ \pi_3 \log(mean\ of\ net\ export\ earning)_{ijt} + \pi_4 Size_{ijt} + \pi_5 age_{ijt}$$
$$+ \pi_6 age^2{}_{ijt} + \varphi_1 log\ markup_{ijt-1}$$
$$+ u_{ijt} \tag{4.7}$$

Here, $Corr(\varepsilon_{ijt}, u_{ijt}) = \rho_{\varepsilon u}$; $SE\ (\varepsilon_{ijt}) = \sigma$

In the Heckman's two step estimation procedure, we first estimate ρ_{ijt} (i.e., the probability of positive mark-up change) using a Probit regression model for equations 4.7.[13] Once we estimate ρ_{ijt} we then calculate the inverse Mill's ratio (λ_{ij}). The estimated λ_{ij} gets placed in the right-hand side of equation (4.6) as an exogenous variable and subsequently we estimate equation (4.6) in Step 2. The Heckman's two step estimation procedure allows us to remove sample selection bias which occurs

approach to control for possible trade policy endogeneity (which arises due to reverse causality between last period's firm-level export risk and returns on current period's firm-level mark-up during our study period. The dynamic panel results remain symmetric with our main results. As our main objective is to empirically estimate the risk aversion elasticities of the main variables of our theoretical model ($\mu_{\pi_{it}}, v_{\pi_{it}}$ and $\partial v_\pi(I^*)/\partial I$) rather than examining any trade policy effect on mark-up, we did not provide the results of our dynamic panel (with lags 1, 2 and 3) in the main text**. The Dynamic Panel results will be available on request.**

[13] We have explored an important source of endogeneity, i.e., lagged mark-up (equation, 4.7) which may cause the self-selection behaviour of firms in terms of increasing their mark-ups (i.e., risk premium) in the subsequent period following a low net export earnings in the previous period.

due to a firm's self-selection behaviour in its mark-up improvement, which depends on its 1st lag mark-up.[14] This creates an endogeneity problem. In the present analysis of firm mark-up for exporting firms, our model incorporates the sample of both positive as well as zero firm-level mark-up improvements across manufacturing firms. Hence, this avoids sample selection bias and the endogeneity problem.

Table 4.3 gives the Heckman's estimation results for all exporting firms with 1st lag of mark-up status. The results remain symmetric with the findings of our main fixed effect models, indicating the robustness of our results. For instance, in our final version of the Heckman's two step estimated model with firm, year and industry-year fixed effects, the coefficient of change in mean deviations of net export earnings due to change in domestic investments in regression column (i.e., Column 5) suggests, if the latter increases by 1 percent the firm-level mark-up increases by 0.009 percent. On the other hand, the coefficient of mean (i.e., average returns from export markets) suggests a 0.022 percent decline in firm-level mark-ups due to one percent increase in mean returns from export market. Thus, our theoretical model remains empirically robust even after correcting for sample selection bias and endogeneity problem. Moreover, interestingly the coefficient of lagged mark-up in selection column (i.e., Column 6) of our final version of the Heckman's two step estimated model remains significant and negative. This implies that there is a higher probability that the risk-

[14] It should be noted that we also extend our analysis further to examine whether the firm-level mark-up is endogenous with its second lag (lag 2). However, the result suggests the absence of endogeneity of firm-level mark-ups at lag 2.

averse exporting firm would increase its risk premium (i.e., firm-level mark-up) if the firm had lower risk premium in the previous period.

Table 4.3: Firm-level Risk Aversion Elasticities with respect to Risk and Returns of Exports for Indian Exporting Firms (with Mark-up-Lag-1)

VARIABLES	(1) Mark-up Exporting Firms	(2) Mark-up Exporting Firms	(3) Mark-up Exporting Firms	(4) Mark-up Exporting Firms	(5) Mark-up Exporting Firms	(6) Mark-up Exporting Firms
	Regression	**Selection**	**Regression**	**Selection**	**Regression**	**Selection**
$log\ (\frac{d\ (mean\ deviation\ of\ net\ export\ earning^2)}{d(investments\ in\ domestic\ raw\ materials)})$	0.008***	-0.044	0.008***	-0.044	0.009***	-0.043
	(0.003)	(0.030)	(0.003)	(0.034)	(0.003)	(0.035)
$log(mean\ deviation\ of\ net\ export\ earning^2)$	0.012***	0.080***	0.009	0.001	0.005	-0.000
	(0.004)	(0.020)	(0.006)	(0.038)	(0.005)	(0.039)
$log(mean\ of\ net\ export\ earning)$	-0.006	-0.018	-0.007	-0.003	-0.022**	-0.000
	(0.012)	(0.073)	(0.012)	(0.080)	(0.012)	(0.079)
Size			0.038	0.245***	0.076**	0.245***
			(0.038)	(0.050)	(0.035)	(0.051)
Age			0.021***	0.014	0.031***	0.014
			(0.006)	(0.010)	(0.009)	(0.010)
Age²			0.000	-0.000*	0.000**	-0.000*
			(0.000)	(0.000)	(0.000)	(0.000)
Lagged log (Mark-up)		-0.158		-0.285**		-0.286*
		(0.162)		(0.147)		(0.153)
Constant	0.442	1.910***	0.241	1.397***	-0.215**	1.394***
	(0.343)	(0.081)	(0.342)	(0.192)	(0.101)	(0.193)
Rho		**0.069**		**0.101****		**0.120***
		(0.052)		**(0.004)**		**(0.073)**
Lambda		**0.010**		**0.014****		**0.013***
		(0.007)		**(0.006)**		**(0.008)**
Firm Fixed Effects	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Year Fixed Effects	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Industry-Year Fixed Effects	**NO**	**NO**	**NO**	**NO**	**YES**	**YES**
Observations	**2445**	**2445**	**2419**	**2445**	**2419**	**2419**
Censored obs	**66**	**66**	**66**	**66**	**66**	**66**
Uncensored obs	**2379**	**2379**	**2353**	**2353**	**2353**	**2353**
No of Firms	**805**	**805**	**794**	**794**	**794**	**794**
Wald chi2	**1.72**	**1.72**	**5.12****	**5.12****	**2.66***	**2.66***

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Concluding remarks

For a risk-averse firm gearing up to export under uncertainty, effect of exchange rate volatility, in the presence of exogenous uncontrollable firm-specific factors (variations in firm size, age, random perturbation in the industry-specific policies etc.) that enhance the uncertainty regarding the fixed costs of exporting, on its decision regarding how much it's worth to invest for exporting is an immensely important issue but has been left unexplored. 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 responses of the decision variable (here optimum investment to enable the firm in exporting activity) in response to the changes in the distributions of not only the spot exchange rate, but also in the background risk in terms of the marginal willingness to substitute risk for return.

After that, we utilise a panel of 840 Indian manufacturing exporters over a time-period of 1995-2017 to perform joint estimation of risk preference structure and risk aversion elasticities. For this purpose, we directly estimate a flexible utility function in a nonlinear mean-standard deviation framework that nests all possible risk preference structures. Then we employ two-step ACF corrected LP methodology to empirically estimate firm-level mark-ups. Using these mark-ups as a proxy for firms' risk-premium, we then estimate a fixed-effects regression model. To control for background risks, we consider not only the firm-level controls (firm-size and firm-age), but also the firm, year and industry-year fixed effects. We also use Heckman's 2-step estimation procedure to control for possible endogeneity. Overall, the empirical findings suggest that the risk preferences of the Indian manufacturing exporters are characterised by 'proper' risk aversion (satisfying both the DARA and 'variance vulnerability' properties of risk preferences).

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