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Are Production Risk and Labour Market Risk Covariant?

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Abstract

While in a given situation the production risk that farmers face may well be independent of the labour market risk, in general these may be highly related in the context of the local labour market. The strength of this relationship has important implications not only for the correct specification of the household model under risk, but also for addressing the issue whether the farm household can use the labour market as a hedge against production uncertainty. Clearly, if the two risks are covariant, the possibility of doing so may be very small. If, instead, they are independent, the farm household may avail of the local casual labour market to balance the production risk it faces. Using a large sample of farmers we find that labour market risk and production risk are not causally related in the Granger sense.

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Are Production Risk and Labour Market Risk 'Covariant'?

When considering labour allocation decisions by a farm household, it is pertinent not *only* to consider production risk faced by the farmer (Roe and Graham-Tomasi [1986], Fafchamps [1991], Kanwar [1991]), or else *only* the uncertainty attaching to off-farm employment (Bardhan [1979]) but *both* kinds of risks simultaneously. While in a given situation these two kinds of risks may well be independent of each other, in general, they may be highly related in the context of the local labour market. The reason for this is not difficult to see. If inimical weather damages crops in a given region, then not only is the farmer in question a victim of this production risk, he is also likely to face greater uncertainty in finding wage employment on other farmers' fields. Ofcourse, this relationship may not be statistically very strong if other (non-farm) sources of wage employment are available to the farmer. For the latter will allow him to balance the increased uncertainty of finding *farm* employment. The strength of the relationship between these two kinds of risks has important implications not only for the correct specification of the household model under risk, but also for addressing the issue whether the farm household can use the labour market as a hedge against production uncertainty. Clearly, if the two risks are covariant, the possibility of doing so may be very small. If, instead, the two risks are independent, the farm household may avail of the opportunities in the local casual labour market to balance the production risk it faces. An indirect test of such covariance would be to test for the statistical significance of the farmer's off-farm labour supply response to variations in production risk. If this response is statistically significant, it could be taken to imply that although the risks in question were covariant, their relationship was not strong enough to negate the possibility of using the labour market as a hedge against production uncertainty. However, a direct test of their covariant relationship would still be helpful, and this is the objective of this paper.

The sample used pertains to 53 farm households residing in the villages of Aurepalle, Shirapur and Kanzara in the Indian semi-arid tropics[1]. Data were available for the ten-year period 1975-84. The sample households were purposively randomly selected so as to reflect the diverse agro-climatic characteristics of the semi-arid regions. Aurepalle is characteristic of regions with Alfisol soils, and low and uncertain rainfall. Shirapur is representative of regions with medium to deep Vertisol soils, coupled with low and uncertain rainfall. Whilst Kanzara is typical of medium Vertisols with relatively high and assured rainfall. The generally small and low productivity character of their asset base coupled with limited local employment opportunities ensured 'some' unemployment/underemployment. In consequence, this sample was quite appropriated for considering issues relating to production and labour market risks.

Section 2 explains the concepts of "production risk" and "labour market risk" in the context of the farm household. Sections 3 and 4 then outline the estimation procedure and results. Finally, section 5 briefly concludes the paper.

2. "Production risk" and "Labour market risk"

We define production risk in terms of revenue risk faced by the farmer. It appears plausible to argue that farmers base their production decisions on expected net returns and the variability of such returns. We propose to approximate these moments by the conditional expectation of actual net revenue and the associated standard deviation. Production risk is then measured as the ratio of the latter to the former, i.e. as the coefficient of variation of net revenue (CVNR). For this purpose, we jointly estimate the conditional mean and variance of the net revenue distribution by regressing current net revenue on lagged net revenue, change in household assets, and a time trend.[2]

The risk associated with labour market employment is captured in terms of the expected real wage rate (ERWA), i.e. as the product of the probability of finding employment in the local casual labour market and the actual real wage rate. The probability of finding employment is measured as the ratio of the actual labour supply to the desired labour supply on the part of the working members in the farm household.[3] Given that this probability will vary between households on the basis of factors such as age, education and caste (as well as their particular village of residence), we derive household-specific estimates of this probability by running a probit regression on the set of regressors mentioned above. The expected real wage rate is then derived by multiplying this probability by the actual real wage rate.

3. Testing for Stationarity

We propose to test for the dependence of labour market risk on production risk in the 'Granger sense' (Granger [1981], Engle and Granger [1987]). This exercise consists of two steps. In the first step we determine whether the individual series on production and labour market risks are stationary. In the second step, using stationary series (which may be transforms of the original series), we then test for whether production risk "causes" labour market risk in the Granger sense.

To execute the first step mentioned above, we conducted Dickey-Fuller unit root tests to determine whether the individual series are non-stationary (Dickey and Fuller [1979, 1981]. For a series Y_t this essentially amounts to testing whether the coefficient of Y_{t-1} in a regression of ΔY_t on Y_{t-1} equals unity. Since the distribution of the test statistic in this case is found to be affected by the presence or absence of a constant term unless a trend variable is also present in the equation, it is often preferred to include both a constant and a trend term in the regression. Phillips [1987] shows that the validity of these tests depends crucially on the error process not being autocorrelated, (although heteroscedasticity is not a problem). In case the errors are autocorrelated, a sufficient number of lagged terms is added to the set of regressors till serial independence is achieved. Thus, the so-called "Augmented Dickey-Fuller regression equation" is:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \alpha_2 Y_{t-1} + \Sigma_k \delta_k \Delta Y_{t-k} + \epsilon_t$$

where k denotes the number of lags and $\epsilon_t \sim \text{NIID}(0, \sigma_\epsilon^2)$. Note that since we had panel data, we pooled the cross-section and time series data by using a separate intercept term for each of the different cross-section units in all our regressions. It is only for convenience that we are writing the intercept as a single constant term.

We tested for serial correlation using the Durbin "large sample test[4]. In the case of both variables (ERWA and CVNR), the error terms are found to be serially independent[5]. This implies that we need not run Augmented Dickey-Fuller regressions for the stationarity tests to be valid.

From the Dickey-Fuller regressions of the two variables, we find that the

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corresponding series are stationary. This may be gauged from the estimation results presented in table 1. Consider the results for the first variable, the expected real wage rate. The null hypothesis of a unit root can be rejected only if the test statistic is smaller than the critical value. The test statistic for the null hypothesis of $\alpha_2 = 0$ is -13.91 which is much smaller than the 10% critical value of -3.13. Further, the test statistics for the hypotheses $\alpha_0 = \alpha_1 = \alpha_2 = 0$ (unit root without drift) and $\alpha_1 = \alpha_2 = 0$ (unit root with drift) are 4.52 and 97.70, which are significant at the 10% level (since they exceed the respective critical values of 4.03 and 5.34. Similar observations may be made for the variable CVNR. Thus, we must reject the null hypothesis of a unit root in the case of both the variables in question. In other words, their time series may be taken to be stationary.

4. Testing for Granger Causality

Let the unrestricted causal model relating the two variables be represented as:

$$ERWA_t = \alpha_0 + \alpha_1 t + \Sigma_{i=1}^{I} \beta_i ERWA_{t-i} + \Sigma_{j=0}^{J} \gamma_j CVNR_{t-j} + u_t$$

$$CVNR_t = \alpha_0' + \alpha_1' t + \Sigma_{k=1}^{K} \beta_k' CVNR_{t-k} + \Sigma_{l=0}^{L} \gamma_l' ERWA_{t-l} + v_t$$

where u_t and v_t are independently distributed Gaussian processes. In testing for whether CVNR 'causes' ERWA we also need to check that the reverse causation does not obtain.

To estimate the above model we need to determine the appropriate lag order in each case. This we do by using the Akaike Final Prediction Error criterion (Hsiao [1979], Judge et. al [1988])[6]. Taking a maximum lag length of three periods, we estimate the Final Prediction Errors for our two variables[7] and the results are given in table 2. The first lines of both panels give the FPEs for the dependent variable regressed on itself lagged various periods[8]. The other rows give the FPEs for regressions including the hypothesized causal variable, lagged various periods[9]. In the first equation, the lag combination (2,1) minimizes the FPE, while in the second equation the optimum combination is (1,1); so that the appropriate estimation model may be written as:

$$ERWA_t = \alpha_0 + \alpha_1 t + \beta_1 ERWA_{t-1} + \beta_2 ERWA_{t-2} + \gamma_0 CVNR_t + \gamma_1 CVNR_{t-1} + u_t$$

$$CVNR_t = \alpha_0' + \alpha_1' t + \beta_1' CVNR_{t-1} + \gamma_0' ERWA_t + \gamma_1' ERWA_{t-1} + v_t$$

At this juncture we would like to point out that the way in which the above criterion is used in the literature may not be entirely satisfactory. We feel that when we hypothesize y_t to be Granger caused by x_t, and are desirous of testing for this causality, then x_t should be included as a regressor anyway. In other words, the inclusion of x_t is advocated on grounds of economic intuition. To put it more strongly, even if the Akaike information criterion tells you not to include x_t (with $FPE[y_{t-1}] < FPE[y_{t-1}, x_t]$ for instance), x_t should be included because theory suggests its inclusion. Only the inclusion of further (lagged) terms should, then, be based on some 'objective' criterion such as Akaike's; because economic intuition may not have anything to add in this case.

Having determined the specific model for estimation, we now test for Granger causality. Of the various causality tests suggested in the literature, the Granger test (Granger [1969], Sargent [1976]) seems to be a relatively preferred choice. This is partly supported by the available Monte Carlo evidence, which reveals the Granger test as more powerful than the Sims test and tests based on cross-correlation procedures (Guilkey and Salemi [1982]; Nelson and Schwert [1982]). Moreover, the Granger test is relatively parsimonious in its data requirements -- the Sims test resulting in fewer degrees of freedom both on account of observations lost in estimation (since the most recent observations are retained for constructing the "leading variables"), and on account of the larger number of parameters to be estimated (namely, for the leading variables).

To conduct the Granger test we proceed as follows. Consider the first equation in the above model. We first regress $ERWA_t$ on the trend, $ERWA_{t-1}$ and $ERWA_{t-2}$. The residuals obtained from this regression are then regressed on all the regressors, i.e. including $CVNR_t$ and $CVNR_{t-1}$. Computing the coefficient of determination from this regression, we then construct the LMF variant of the Lagrange Multiplier statistic (see Charemza and Deadman [1993]) as $LMF = ((T-h)/k).R^2/(1-R^2)$ where T is the number of observations, k is the number of lags and h is the total number of regressors used. Under the null hypothesis, this statistic is distributed as F(k,T-h). Table 3 provides the regression results for the above model, along with the values for the corresponding LMF statistics. We find that LMF = 0.6395 for the ERWA variable, which is much smaller than the 10% critical value F(2,366) = 2.2950. In other words, we cannot reject the null hypothesis of the joint insignificance of $CVNR_t$ and $CVNR_{t-1}$ in Granger causing $ERWA_t$. Similarly, we note that LMF = 0.9282 for the variable $CVNR_t$, which again falls short of the 10% critical value F(2,420) = 2.2930. Therefore we cannot reject the null hypothesis of the joint insignificance of $ERWA_t$ and $ERWA_{t-1}$ in Granger causing $CVNR_t$. Putting both these results together, we conclude that the variables ERWA and CVNR and not causally related in the Granger sense. More simply, we do not find evidence of labour market risk depending on production risk[10].

5. Conclusions

In a less developed country setting, the predominant bulk of farms are 'small' and 'medium' farms. Since these farms are too small to fully, gainfully employ all the available household labour over the agricultural year, they are characterised by substantial amounts of excess labour which can be (and often is) supplied in the daily casual labour market if necessary. While on the one hand these farmers are subject to the risks relating to production on their own farms, on the other they are subject to the risks of labour market employment. Since a large part of this employment is usually cultivation-related work on other people's farms, it is possible that production risk and labour risk are covariant. However, if alternative sources of (non-cultivation-related) employment are available, these risks need not be significantly covariant. In fact, this is what we discover for a large sample of Indian farmers operating in the semi-arid tropics. In addition to cultivation work these farmers could also find work relating to animal husbandry, construction, repairs and maintenance, trade, marketing and transport, domestic work and other work (such as handicrafts etc.). Quite possibly, the latter types of employment opportunities were enough to prevent any significant dependence of labour market risk on production risk[11]. This has at least two important implications. Theoretically, in modelling labour allocation decisions by the farm household, we need not consider the joint distribution of these risks. Assuming them to be independently distributed makes the model easier to estimate. Empirically, it raises the possibility of the farm household hedging against production risk through variations in its wage labour effort.

Notes

1. These data were collected by ICRISAT -- International Crops Research Institute for the Semi-Arid Tropics. For details see Singh et.al. [1985].

2. Walker and SubbaRao [1982] find the assumption of normality for the net returns distribution to be tenable as a first approximation. See Kanwar [1991] for a more detailed discussion of this specification.

3. Since estimates of involuntary unemployment were available at the individual respondent level, we derived desired labour supply as the sum of the actual labour supply and involuntary unemployment.

4. This involved regressing the residuals obtained from the Dickey-Fuller regression equations ($\hat{\epsilon}_t$) on the residuals lagged one period ($\hat{\epsilon}_{t-1}$), and the other regressors (namely t and Y_{t-1}). The significance of the lagged residuals term is then determined in the usual manner.

5. The coefficient of $\hat{\epsilon}_{t-1}$ is - 0.5568 in the case of variable ERWA and 0.5148 in the case of bariable CVNR, both of which are less than 1.645, the large sample critical value for a two-tail test at the 10% level.

6. According to Hsiao's original method we first determine the optimum lag length for a given variable y_t by choosing that lag which minimized the FPE for y_t lagged on itself alone. Given this optimum lag order for y_t, we again compute the FPEs for y_t but now including x_t terms of various lags as additional regressors. The lag order combination which minimizes the FPE is taken to be the optimum combination. However, Judge [1988] points out that Hsiao's original method may not always be able to identify the

optimum lag order. He suggests that it is preferable to estimated the FPEs for all possible lag order combinations for y_t and x_t (after deciding on the maximum admissible lag lengths), and then simply choosing the lag combination that minimizes the Final Prediction Error. Note that in our case both methods lead to the same solution.

7. We chose the maximum lag to be three on account of the rather short time series that we have (just 9 periods), although degrees of freedom are not a problem on account of the large cross-section.

8. The Final Prediction Error in this case is computed as:

$FPE(i) = (T+i+1)/(T-i-1).RSS/T$

where T is the actual number of observations used in estimation, i is the lag length, and RSS is the residual sum of squares. As the lag length increases, the first term in the above expression increases but the second term decreases. These opposing factors are assumed to be balanced optimally when their product (the FPE) reaches a minimum.

9. The Final Prediction Error is now computed as:

$FPE(i,j) = (T+i+j+1)/T-i-j-1).RSS/T$

where j is the lag length pertaining to the causal variable, and the other variables are defined as before.

10. Or vice versa, except that we are not interested in the reverse causation since it is not economically meaningful.

11. Ofcourse, one could further test the hypothesis that production risk is related to the risk of finding cultivation-related work in the labour market. However, we were prevented from doing so by the unavailability of the "probability of finding cultivation-

related work" as distinct from the "probability of finding employment". Moreover, this would still leave the larger issue of the dependence of labour market risk on production risk unadressed.

Table 1

Dickey-Fuller Tests for Stationarity

Variable: ERWA

Number of lags = 0; Number of observations = 424

Null Hypothesis	**Test Statistic**	**Asymptotic 10% Critical Value**
$\alpha_2 = 0$	-13.91	-3.13
$\alpha_0 = \alpha_1 = \alpha_2 = 0$	4.52	4.03
$\alpha_1 = \alpha_2 = 0$	97.70	5.34

Variable: CVNR

Number of lags = 0; Number of observations = 424

Null Hypothesis	**Test Statistic**	**Asymptotic 10% Critical Value**
$\alpha_2 = 0$	-26.34	-3.13
$\alpha_0 = \alpha_1 = \alpha_2 = 0$	13.12	4.03
$\alpha_1 = \alpha_2 = 0$	346.85	5.34

Table 2

Final Prediction Errors

ERWA

j↓\ i→	0	1	2	3
-	0.2785502	0.2783088	0.2772661	0.2789526
0	0.2783259	0.2781984	0.2771957	0.2788804
1	0.2769700	0.2770508	0.2752003	0.2768683
2	0.2785011	0.2786066	0.2766961	0.2783731
3	0.2802572	0.2803616	0.2784382	0.2801294

CVNR

l↓\ k→	0	1	2	3
-	3.369390	3.292408	3.312658	3.331764
0	3.366677	3.285404	3.305499	3.324582
1	3.353874	3.269094	3.288892	3.307621
2	3.369898	3.289063	3.309027	3.327862
3	3.390772	3.309378	3.329466	3.348086

Table 3

Granger Causality Tests

Equation 1 -- Dependent variable ERWA

Variable	**Estimated Coefficient**	**Standard Error**	**P-value**
T	0.19465	0.02059	0.000
$ERWA_{t-1}$	0.19943	0.06109	0.001
$ERWA_{t-2}$	-0.069500	0.07036	0.324
$CVNR_t$	0.0033755	0.01609	0.834
$CVNR_{t-1}$	0.0059702	0.006766	0.378

$R_2 = 0.6224$; $\sigma = 0.56019$; RSS = 98.223; ln(L) = -279.904

Test statistic for the Granger test: LMF = 0.6395

Equation 2 -- Dependent variable CVNR

Variable	**Estimated Coefficient**	**Standard Error**	**P-value**
T	-0.076265	0.1381	0.581
$CVNR_{t-1}$	-0.11057	0.04222	0.009
ERWA	0.17001	0.4180	0.684
$ERWA_{t-1}$	0.33115	0.4481	0.460

$R_2 = 0.0.1490$; $\sigma = 4.3491$; RSS = 6941.8; log(L) = -1194.29

Test statistic for the Granger test: LMF = 0.9282

Note: Regression estimates for constant terms not reported because a separate intercept was used for each of the 53 units.

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