Diffusion of Agricultural Innovations in India
The case of Bivoltine hybrid technology in South Indian sericulture
GK. Rajesh*

(_abstract)

India is world’s second largest silk producer. However its sericulture is marked by low productivity and poor quality of produce. Because of this reason India imports large quantities of raw silk mainly to meet the demands of the high speed power-looms. Thus the country has become the largest importer of silk also. However its potentials for expanding silk production is proven, given the increasing domestic as well as global demand for silk and silk products. Because of the inability to maintain quality standards, India is not only unable to compete in the international silk market but also facing tough competition in the domestic market with imported silk. The large scale silk import has affected domestic sericulture causing considerable labour displacement, which is a cause for important socio economic concern. It is of general consensus that adoption of Bivoltine hybrid silkworm is the only answer to this problem. But the bivoltine technology diffusion in India has been slow in spite of serious efforts. In this context an empirical study was taken up to look into the factors determining the diffusion of bivoltine hybrid silkworm in India, in the frame work of the economic theory of diffusion of innovations. The empirical study was done in the sericulture belt of Mandya district of Karnataka.

The results stress the importance of economic factors on the adoption decesion. In agreement with the empirical literature on adoption, age and education are found to impact negatively on bivoltine adoption decision. So also farm size exerts a positive influence. Mitigation of perceived risk and uncertainty are found to be important on adoption of bivoltine hybrid. While family labour availability discouraged bivoltine adoption, credit encouraged it. The importance of profitability is emphasised by the results.

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Introduction

The process of technological change is understood in terms of the Schumpeterian trilogy of Invention, Innovation and Diffusion (Rogers; 1962, Stoneman and Diederen, 1994). Diffusion research, in the past century had analysed the manner in which innovations are adopted or rejected temporally and spatially by participants in a social system. A major goal of diffusion research in agriculture has been to identify factors, which contribute to the variations in adoption behaviour of farmers. Once these factors are known they can be manipulated to expedite the diffusion rate among the potential adopters.

The spread of new agricultural technologies have received attention of researchers because they can raise the income of smallholders (Ruttan 1977; Barham et al. 1995), generate broad and equitable benefits to society (Lipton and Longhurst 1989; De Franco and Godoy 1993), and lower pressure on renewable natural resources (Almeida and Campari 1994). The importance of diffusion of technology in agriculture has been realized by economists since 1950s. After Griliche’s (1957) landmark study of diffusion of hybrid corn, researchers of adoption have focused on the role of economic variables (principally prices) in the diffusion of new technologies. Since then a large body of work surfaced inquiring the nature and causes of differential diffusion rates of various agricultural technologies. This paper analyses the reasons behind slow diffusion of an important innovation in South Indian sericulture namely ‘Bivoltine hybrid technology’; in the theoretical frame work of ‘economics of technology diffusion’ and in the light of an empirical study conducted in Mandya district of Karnataka state.

Indian sericulture industry- importance, issues

India is world’s second largest silk producer. It is also the largest consumer and importer of silk and silk goods (UN Comtrade data 2007). Sericulture is important to Indian
economy as a cottage industry spread over 53814 villages employing nearly 56 lakhs people (Central silk Board data base, 2007). As a labour intensive activity practiced throughout the year it is identified as a means for rural employment generation and as a remedy for seasonal unemployment (Jayaram et al. 1998). The other merits of sericulture as an agro-industry are: its short gestation period to establish, potential for regular returns to the farmers, reellers and weavers, environment friendly production and processing technologies, potential for farm diversification, cash flow from rich to the poor, sustainability as a rural based activity involving family labour and women and high value addition to the end products with potential export markets (Bencharmin and Giridhar, 2005). The Indian sericulture industry is currently faced with the problems of stagnation in production, low productivity, poor quality of produce, high cost of production and competition from cheap raw-silk imports.

The sericulture industry is built upon two living organisms: an insect namely silkworm and its food plant namely mulberry. Thus the quality and quantity of raw-silk output are primarily dependent on the genetic potential of mulberry and the silkworm breeds. Almost 95% of silk produced in India is from traditional low yielding indigenous multivoltine silkworm varieties or cross breeds which are relatively poor yielders (CSB database 2007). The cocoons produced by them are unsuitable for reeling in sophisticated reeling machines and the raw-silk produced from which is characterised by lower filament length and, lesser tensile strength leading to breakages making it unfit for high speed power loom weaving (Kumaresan et al., 2002). Thus the power-loom industry is heavily dependent on imported Chinese raw-silk which is of superior quality (Vasumathi, 2000 and Thomas et.al, 2005a). The indigenous raw silk is largely consumed by the handloom sector and partly by the power loom sector as weft (Vasumathi, 2000). The import price of raw silk has been lower than the domestic raw silk, as the cost of production of Indian silk is high (Kumaresan, 2002). Moreover as shown by Naik and Babu (1993), the price of imported Chinese raw-silk is dependent on the prevailing prices of Indian raw-silk, though the causative nature of indigenous raw-silk price has not been clearly elucidated. This has affected the indigenous raw-silk prices and in turn the domestic cocoon prices (Tikku, 1999). This could probably be one of the reasons for large scale uprooting of mulberry plantations which resulted in considerable labour displacement in the farm sector (Central silk Board data base, 2007). There is a growing demand supply gap of raw silk in the domestic industry. Naik and Babu (1993) estimated that the total high quality silk production in India could meet at the most 60% of the estimated demand.

A solution to the qualitative and quantitative problems of Indian silk industry is popularization of high yielding silkworm hybrids that can also yield better quality silk. The bivoltine silkworm races prevalent in the temperate countries are characterized by high productivity (800-1250 kg cocoons / hectare of mulberry) and high quality silk as compared to multivoltine races of tropical countries (160-440 kg cocoon / ha. of mulberry) (Jayaswal etal, 2001). The comparative performance of Bivoltine hybrid vis-a-vis Cross breed furnished in table 1 clearly establishes the superiority of Bivoltine hybrid. The superiority of Bivoltine hybrids is not confined to the quality of silk they produce. The hybrid yields significantly

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1 Though there are four species of silkworms the mulberry silkworm Bombyx mori accounts for the lion share of global silk production and this study is exclusively on mulberry silk.

2 Crossbreed (CB) is a hybrid between Pure Mysore (an indigenous multivoltine race known for its hardiness), and NB4D2, a bivoltine breed developed in India. CB is comparatively easy to rear but yield relatively poor quality silk.

3 Weft is the yarn running breadth wise in the fabric, the mechanical tension on which is lower as compared to that on the warp, which run length wise. As warp is stretched under tension, if the yarn is not strong enough it is liable to break, rendering the weaving process difficult. The tension on warp is more in power-looms as compared to hand-loom
higher quantities of cocoons and thus supposed to be more remunerative to farmers. The comparative data furnished in table 2 is illustrative of this.

**Table 1. Comparative performance of BV hybrids and Cross Breeds**

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Cross Breed (PM X NB$_2$D$_2$)</th>
<th>Bivoltine hybrid (CSR$_2$ X CSR$_4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Yellow</td>
<td>White</td>
</tr>
<tr>
<td>Silk quality$^4$</td>
<td>B</td>
<td>2A to 4A</td>
</tr>
<tr>
<td>Renditta$^5$</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Filament length$^6$</td>
<td>750 m.</td>
<td>1150 m.</td>
</tr>
<tr>
<td>Yield per 40,000 larvae</td>
<td>50 kg.</td>
<td>70 kg.</td>
</tr>
<tr>
<td>Survival %</td>
<td>70%</td>
<td>53%</td>
</tr>
<tr>
<td>Cocoon price per kg. (Rs.)</td>
<td>100-150</td>
<td>180-240</td>
</tr>
</tbody>
</table>

Source: Dandin, S.B; H.K. Basavaraja and N. Suresh Kumar (2005)

**Table 2. Comparison of bivoltine and cross breed cocoon production (per annum)**

<table>
<thead>
<tr>
<th>Items</th>
<th>BV Hybrids</th>
<th>Cross Breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf cost</td>
<td>27864.49</td>
<td>18825.83</td>
</tr>
<tr>
<td>Silkworm seed</td>
<td>1782.44</td>
<td>3766.69</td>
</tr>
<tr>
<td>Disinfectants and materials</td>
<td>7301.97</td>
<td>3755.73</td>
</tr>
<tr>
<td>Labour</td>
<td>13566.9</td>
<td>11975.61</td>
</tr>
<tr>
<td>Depreciation on fixed capital</td>
<td>32972.45</td>
<td>25485.78</td>
</tr>
<tr>
<td>Other costs</td>
<td>3232.12</td>
<td>5122.92</td>
</tr>
<tr>
<td>Total cost</td>
<td>86720.37</td>
<td>68932.56</td>
</tr>
<tr>
<td>Revenue</td>
<td>123519.92</td>
<td>86175.33</td>
</tr>
<tr>
<td>Net return per annum</td>
<td>36799.55</td>
<td>17242.77</td>
</tr>
<tr>
<td>B:C ratio</td>
<td>1.42</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Source: Kumaresan, 2002

Considering this the Tropical Sericultural Technology was developed in India during 1970’s and a National Sericulture Project (NSP) was launched in 1990 with World Bank support (World Bank, 1997). The major thrust of these projects was development of bivoltine silkworm hybrids and appropriate agronomic practices for rearing them and development of sophisticated technology for processing cocoon and silk. Against the 1000 tons per annum target of BV hybrid cocoon production under NSP, only 400 tons was realised (World Bank, 1997).

**Statement of the problem**

The efforts to popularise Bivoltine hybrids in India met with limited success at the adoption level (Ramakrishnan, 2001 and Kumaresan, 2002). It is seen that at present bivoltine silk forms below 10% of total raw-silk production, the remaining being produced from traditional inferior breeds and cross breeds (CSB, 2011). This indicates that only below 10% of the farmers have adopted bivoltine hybrids in the country and the remaining are with conventional cross breeds or other inferior breeds, the silk produced out of which is of low quality suitable for handlooms only. Chart 1 illustrates the diffusion of bivoltine hybrid in

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$^4$ The international quality standards prescribe grading of raw silk from A to D, A being the higher quality. Above A grade a further classification in the ascending order 2A, 3A etc. is done.

$^5$ Renditta is the measure that indicates the quantity of cocoons required to produce one kilogram of raw silk, for the crossbreed it is above 8. This means that an average of 8 kg cocoons are required to produce one kg of raw silk. On the other hand, the new bivoltine hybrids have the renditta less than six. Hence, the silk production can be improved by 30 per cent by merely switching over to bivoltine raw silk production.

$^6$ Filament length is the length of the continuous filament that could be recovered from the cocoon.
major silk producing states which contribute to 90% of Indian silk, for the period from 1990 to 2012. Except Tamilnadu and Maharashtra, no other states have shown any encouraging trend in diffusion.

Chart 2 gives the contribution of various states to total cocoon production. It shows that the major contributories are Karnataka and Andhra Pradesh (where diffusion of BV-hybrid is very low) and Tamilnadu and Maharashtra, where BV-hybrid diffusion is comparatively faster, have very small shares in total cocoon production. However, from Chart 3 it can be seen that Tamilnadu has the greatest share (33%) of total BV-hybrid production in the country. Thus the diffusion of BV-hybrid in Tamilnadu is a commendable achievement, which makes the case of Tamilnadu, a worthy research topic to pursue. Nevertheless this paper is confined to the BV-hybrid diffusion status of Karnataka, the largest contributor to silk production in the country.

Chart: 1
Diffusion of BV Hybrid in various states in India 1990 to 2012 (22 yrs)

Source: CSB data base 2012
Huge investments made towards developing suitable *bivoltine* hybrids, developing appropriate agronomic practices and extension efforts have not resulted in matching diffusion of the *bivoltine* hybrid in the country.
It is established that without producing bivoltine silk in sufficient quantities, India cannot hold its ground in the domestic silk market, let alone compete in the global market. Considering the fact that the domestic sericulture and silk industry is undergoing a ‘struggle for existence’ in the post liberalisation era, facing tough competition from cheap imports of raw silk and silk products mainly from China (Directorate General of Anti-Dumping and allied Duties, 2005), the issue of slow diffusion of bivoltine hybrid silkworm assumes importance.

This issue has not been subjected much to systematic economic investigation. The available, limited numbers of studies on this topic were conducted by specialists in agriculture extension. Their studies dealt either with the problem of differential acceptance as a function of status, role and motivation or with the problem of communication of innovations. Therefore the present study approaches the problem from the perspective of economics of technology diffusion.

**Objective of the study**

The objective of the present study is to find out the factors influencing the decision of Indian sericulture farmer on adoption of Bivoltine hybrid silkworm.

**Methodology and source of data**

Both primary and secondary data were used for the study. The study was primarily based on the micro data generated from a sample survey conducted in Sreerangapattanam taluk, Mandya district, Karnataka state. Out of the five sericultural ranges in the taluk two ranges (comprising of 22 villages and 665 farmers) were selected by purposive sampling method considering large number of farmers and contiguity of farms for easiness of data collection. From the entire list of farmers of these ranges 71 farmers were selected at random. The data was collected through direct interview method by using a pre-tested schedule. The data was analysed and a ‘Probit Regression model’ was constructed.

The categorical dependent variable namely ‘BV hybrid adoption decision, took either value 1 (YES) or 0 (NO). Since the majority respondents have reared both Bivoltine hybrid and Cross breed silkworm batches at some point of time during the year, a bench mark of 50% was used to categorise them. According to this if Bivoltine hybrid forms at least 50% of a farmer’s total annual silkworm seed consumption, he is designated as a BV hybrid adopter and if the adoption percentage is less than 50% he is designated as a non adopter.

The relationship between selected explanatory variables and the BV hybrid adoption decision was analysed by estimating a probit regression model. The probability that farmer ‘i’ adopts bivoltine hybrid is modeled as a function facet of explanatory variable X as given below

\[
P(Y_i = 1 | X_i) = \Phi(X_i'b)
\]

Where \(X_i\) contain variables related to farmer ‘i’. \(\Phi\) is the cumulative standard normal probability distribution function

The 16 explanatory variables used are as follows. Their short forms furnished in parenthesis.

1. Age of the farmer (‘Age’): The age of the farmer is in years as reported by the farmer
2. Social participation of the farmer (‘Soc part’): In order to measure the social participation of farmers the respondents were asked whether they participate in any of the following seven events viz. political parties, panchayath, farmers club, private/voluntary organizations, school parent-teacher association, resident’s

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7 The various reports and studies available are mostly departmental studies undertaken by central and various state governments. Most of the economic investigations undertaken by western scholars were restricted to the period up to 1930 may be the period up to when there was active western interest in silk. Sinha (1989) reported that “…within a substantial body of literature on silk production systematic information on the socio economic dimensions of the activity is lacking”
associations or any other organizations during the previous year. One mark was
assigned to each participation and the total count was taken as an index.

3. Farm Size (‘Land Tot’) represents the total land area owned by the farmer and is used
to capture the effect of farm size on adoption decision

4. Ratio of annual intake of silkworm eggs to mulberry acreage (‘Ra egg-mulb’), which
is the ratio of total silkworm eggs or Chawky reared worms8 (both BV and CB)
purchased by the farmer during the previous year to his mulberry acreage. This
variable is taken as a measure of the farmer’s infrastructure and entrepreneurial
capacity.

5. Ratio of mulberry acreage to total land holding (‘Ra Mulb-Tot’) is used as a proxy for
the relative importance attached by the farmer to sericulture. When the relative
importance of sericulture is more it is expected that the farmer’s dependency on it for
his livelihood is more and it is more probable that the farmer adopt the new
technology.

6. Ratio of total annual cocoon production to the mulberry acreage [Ra coc-mulb] is the
ratio of the total quantity of cocoon produced by the farmer (both bivoltine hybrid and
cross breed) during the previous year to the total mulberry area under his disposal.
This is used as a measure of productivity which in turn is determined by his ability to
harvest successful crops. Better productivity leads to increase in net returns and might
influence bivoltine hybrid adoption decision.

7. Difference in annual average yield between CB and bivoltine hybrid [Diff av yld CB-
BV] is calculated by subtracting the yield per 100 layings9 obtained by the farmer for
bivoltine hybrid from that of cross breed, during the previous year. It is expected that
this variable will have a negative influence on the bivoltine adoption decision, when
the increase in this value is indicative of better performance of CB10 as compared to
BV.

8. Difference between the maximum and minimum price received by the farmer for CB
cocoon [CB Pmax-min] is arrived at by subtracting the minimum price received by
the farmer for CB cocoons from the maximum price for the same during the previous
year. This variable is expected to have a negative impact on the BV adoption decision

9. The number of mass contact programs attended by the farmer [Mass contact 0/1] This
is a indicates whether the farmer has participated in any mass contact programs such
as sericulture krishimela, exhibition, field day etc. which may positively influence his
BV adoption decision by reducing uncertainty and his perceived risk.

10. Sericulture experience [Exp]: Number of years of total Sericulture experience, is used
as a proxy variable for uncertainty which is expected to impact the farmers BV
adoption decision positively.

11. Education level (Edn): This was recorded in number of years of formal education
received by the farmer starting from ‘0’ for the uneducated. It is assumed that with
increasing levels of education the tendency to adopt BV hybrid increase.

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8 The term ‘chawky’ refers to the young silkworm up to the age of about 12 days after hatching. Separate rearing
of these young worms by exclusive Chawky Rearing Centers (CRC) is a recommended practice to ensure proper
care and healthy upbringing of worms which will be sold to the farmer by the CRC instead of eggs directly. This
not only gives a better crop but also saves time of farmer, permitting him to take more number of crops round
the year.

9 Layings means egg masses. 100 layings (or corresponding chawky worms) gives 40,000 individual eggs or
worms. The term average yield means cocoon produced in kg. out of 100 layings.

10 When we take the difference as “average yield of CB minus average yield of BV” a positive value means that
average yield of CB is higher than that of BV. That means increase in this value implies lesser profitability of
BV.
12. Labour availability (Fam lab): Labour availability to the farmer is captured in the variable as the family labour available in the household. It is assumed that availability of family labour will encourage farmer to adopt bivoltine hybrid.

13. Credit [Credit 0/1]: Availing credit facility by the farmer is expected to encourage adoption of bivoltine hybrids among farmers.

14. Number of Extension contacts by government agency (Extn cont): It is expected that the extension contacts from the government agencies will have a positive influence on bivoltine hybrid adoption by farmers.

15. Extension by the private CRC (Extn pvt CRC): The extension contacts from the private Chawky Rearing Center are expected to have a negative impact on bivoltine adoption decision of the farmers.

16. Government subsidy (Subsidy 0/1): Thus government subsidies might positively influence adoption of bivoltine hybrid.

Results and discussion

The Probit model was estimated using maximum likelihood method. The results are reported in table 3. As there are 16 explanatory variables, placing all of them in a single regression would reduce the degrees of freedom drastically. Therefore the estimation is done using five regression models each containing seven variables at a time. The chi square values reported under each equation tests the null hypothesis that all coefficients in the model except the constant term are zero. Given the degrees of freedom it is found that the null hypothesis is rejected in all the five estimated equations. Thus each of these different combinations of explanatory variables in the probit model jointly has significant effect.

Model 1 gives the relationship between age of the farmer and BV adoption. Age of the farmer was found to have a significant negative impact on the bivoltine adoption decision of the farmer. The result is in conformity with the theoretical postulate and are in agreement with the findings of Shetty (1966) and Subrahmanian et.al. (1982) that the middle age group show greater tendency to adopt recommended farming practices. The older farmers are too traditional and security conscious, do not take the risk of adopting the innovation. Another reason for this may be that being in a traditional sericultural area; more age also means more experience. The older farmers (with the exemption of the too traditional and risk averting ones) by virtue of their long experience might be able to harvest better crops using the highly productive but more susceptible BV hybrids. Thus age appears to be a decisive factor in adoption of BV hybrids.

Social participation of the farmer does not reveal any significant influence on BV adoption decision, as per models 3 and 4. However Participation in mass contact programmes during the previous year has a significant positive impact on BV adoption decision as per models 1 and 2. This implies not only that awareness is an important factor in determining BV adoption decision but also that the mass contact programs are effective.

The variable Social participation was used as a proxy for the uncertainty reducing factor which will positively influence the farmers BV adoption decision by reducing uncertainty and perceived risk by acquiring more information.

The variable ‘experience’ is found to impact positively on bivoltine adoption decision of the farmer as given by models 1, 2, 4 and 5. In these models ‘number of years of experience’ has been used as a proxy for the risk bearing capacity of the farmer. Long experience also imply that the farmer has been exposed to many silkworm breeds and can make a better judgement of the bivoltine hybrid than a novice in the field. The experienced farmer could also be expected to have the confidence to handle bivoltine hybrid which is prone to diseases leading to crop losses. Thus the farmer by virtue of his experience may overcome the ‘perceived risks’ of crop losses and adopt BV hybrid. As both the variable used to capture perceived risk and uncertainty reduction have shown positive influence on BV adoption decision, it can be inferred that risk and uncertainty play a vital role in poor
adoption and diffusion of the BV hybrid. Thus the promotional agencies should consider this aspect also.

Table 3. Probit regression results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model -1</th>
<th>Model -2</th>
<th>Model -3</th>
<th>Model -4</th>
<th>Model -5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-.1316925 [0.13]</td>
<td>-2.118839** [-2.62]</td>
<td>-.9958572 [-1.49]</td>
<td>-.1669868 [-0.26]</td>
<td>.8771456 [0.83]</td>
</tr>
<tr>
<td>Age</td>
<td>-.0613273* [-2.39]</td>
<td>-.126698* [-2.40]</td>
<td>-.146846* [-2.53]</td>
<td>.0672721 [0.36]</td>
<td>.1294353 [0.62]</td>
</tr>
<tr>
<td>Edn</td>
<td>-.126698* [-2.40]</td>
<td>-.146846* [-2.53]</td>
<td>.0672721 [0.36]</td>
<td>.1294353 [0.62]</td>
<td>.030957 [1.08]</td>
</tr>
<tr>
<td>Fam lab</td>
<td>.0672721 [0.36]</td>
<td>.1294353 [0.62]</td>
<td>.030957 [1.08]</td>
<td>-.2817048* [-2.42]</td>
<td>-.4219281** [-2.56]</td>
</tr>
<tr>
<td>Land Tot</td>
<td>.2320935* [2.31]</td>
<td>.0246611 [0.24]</td>
<td>.0323301 [0.34]</td>
<td>.0045317 [0.37]</td>
<td>.0045317 [0.37]</td>
</tr>
<tr>
<td>Ra Mulb-Tot</td>
<td>2.104048** [2.64]</td>
<td>2.051582* [2.26]</td>
<td>1.734529* [2.31]</td>
<td>1.734529* [2.31]</td>
<td>1.734529* [2.31]</td>
</tr>
<tr>
<td>Extn cont</td>
<td>.0323301 [0.34]</td>
<td>.0045317 [0.37]</td>
<td>.0045317 [0.37]</td>
<td>.0045317 [0.37]</td>
<td>.0045317 [0.37]</td>
</tr>
<tr>
<td>Diff av yld CB-BV</td>
<td>-.0486666** [-2.96]</td>
<td>-.0486666** [-2.96]</td>
<td>-.0486666** [-2.96]</td>
<td>-.0486666** [-2.96]</td>
<td>-.0486666** [-2.96]</td>
</tr>
<tr>
<td>Credit 0/1</td>
<td>.8866021* [1.94]</td>
<td>-.234289** [-2.88]</td>
<td>-1.687972* [-2.42]</td>
<td>-2.046914* [-2.32]</td>
<td>-2.046914* [-2.32]</td>
</tr>
<tr>
<td>Extn pvt CRC 0/1</td>
<td>1.030694* [2.28]</td>
<td>1.645243** [2.91]</td>
<td>1.746456** [2.98]</td>
<td>1.31716** [2.67]</td>
<td>2.138132** [3.41]</td>
</tr>
<tr>
<td>Mass contact 0/1</td>
<td>1.030694* [2.28]</td>
<td>1.645243** [2.91]</td>
<td>1.746456** [2.98]</td>
<td>1.31716** [2.67]</td>
<td>2.138132** [3.41]</td>
</tr>
<tr>
<td>Subsidy 0/1</td>
<td>1.030694* [2.28]</td>
<td>1.645243** [2.91]</td>
<td>1.746456** [2.98]</td>
<td>1.31716** [2.67]</td>
<td>2.138132** [3.41]</td>
</tr>
<tr>
<td>LR chisquare [ Prob chisquare]</td>
<td>29.12 [0.0001]</td>
<td>39.58 [0.0000]</td>
<td>37.49 [0.0000]</td>
<td>40.73 [0.0000]</td>
<td>63.790 [0.000]</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>.02993</td>
<td>.4069</td>
<td>.3853</td>
<td>.4187</td>
<td>.6557</td>
</tr>
<tr>
<td>No. of observations</td>
<td>71</td>
<td>71</td>
<td>71</td>
<td>71</td>
<td>71</td>
</tr>
</tbody>
</table>

* Significant at 5%
** Significant at 1%
Note: Figures in brackets are z values except for LR chisquare where P values are reported.

The two proxy variables representing farm size are found to be significant. Size of total land holding has a significant positive influence in BV adoption as given by model 1. This implies that the farm size indirectly impacts on hybrid adoption decision through several factors namely fixed adoption costs, risk preferences, human capital, credit constraints, labor requirements, tenure arrangements etc as found by Feder, Just and Zilberman (1985). Ratio of number of eggs reared by the farmer per year to the mulberry acreage has a highly significant positive impact on BV adoption decision, as postulated (given by models 4 and 5). This indicates that farmers with higher infrastructure facilities for rearing more number of worms per unit area, who are also able to produce more leaf per unit area, tend to adopt BV hybrid. Thus mulberry leaf productivity and infrastructure capacity could be a major determinant of BV adoption. Both these variables indirectly represent the economic status of the farmer. From this result it can be deduced that bivoltine hybrid adoption is favoured by the comparatively well to do farmers, who are able to buffer against the shocks of crop failure, able to meet the infrastructure requirements and the extra cost involved, and to overcome the perceived risks and uncertainties through their better exposure through mass media etc.

Ratio of mulberry acreage to total land holding as given by models 1, 2 and 3 has a highly significant positive influence on BV adoption decision by the farmer. This ratio indicates the relative importance attached by the farmer to sericulture among all his farming activities. It is understood from the result that if the relative importance of sericulture is more the farmer’s dependency on it for his livelihood is more and it is more probable that the farmer adopt the BV hybrid technology. Thus farmers who cultivate a substantial portion of their land with mulberry tend to adopt BV hybrids more. This decision inspite of the potential risk involved in it is difficult to understand. For a clearer understanding of this decision making process a detailed investigation is to be conducted taking into account the relative share of mulberry in the total of various size classes of land holding across different income groups.

All the three variables related to profitability of the enterprise and relative profitability between CB and BV rearing are found to be significantly influencing the BV adoption decision indicating the importance of profitability in adoption decision of the farmer. Difference between the maximum and minimum price per kg. obtained by the farmer for CB cocoon during the previous year has created a significant negative impact (at 1% level) on the BV adoption decision (model 3) and is in accordance with our hypothesis. This is because, the increase in this value is indicative of an increase in the maximum price received for CB cocoon. This means that the bivoltine adoption decision of the farmer has a bearing on the relative (maximum) price per kg of CB cocoon. If the farmer gets a higher price for CB cocoon his subsequent adoption decision doesn’t favour BV. Difference in average yield of CB and BV hybrids reared by the farmer during the previous year has a significant negative impact on the BV adoption decision (model 5). This implies that as the average yield of CB increases in comparison with that of BV the subsequent adoption decision will not be in favour of BV. In case of the farmers rearing both the breeds this variable gives the yield difference and hence comparative profitability of the two breeds at the farmer’s level. Ratio of total annual cocoon production to the mulberry acreage is found to have a significant negative influence on the BV hybrid adoption decision of the farmer (models 4 and 5). This ratio is a measure of the farmer’s productivity which in turn is determined by his ability to harvest a successful crop and disease management. The regression result points to the fact that farmers with higher productivity of land (out of both bivoltine and cross breed rearing) during the previous one year are averse to adopt bivoltine. However the results pertain to one single year only. Nothing definite can be said about the
outcome because the productivity analysis was confined to only one year. More analysis of more number of years is necessary to establish the linkage between productivity and adoption.

Number of years of formal education received by the farmer has a significant negative impact on the adoption decision as illustrated by models 1 and 2. This is a disturbing finding since the theory of diffusion and majority of empirical studies do not support it. However we hope that an impartial analysis of the present sericulture scenario in India will explain this. We have two breeds, the traditional Cross Breed, though low yielding is sure to yield a reasonable crop with minimal attention and inputs use. The bivoltine hybrid is a better yielder but notorious for its proneness to disease and demand for more food and extra care. Thus there is a tradeoff between expected profit and perceived risk in bivoltine sericulture. The comparative advantage is determined by the relative profitability. Thus when market prices of Bivoltine cocoon are low, difference in net returns tends to be small. In such circumstance educated farmers who keep accounts of their profit and losses tend to disadopt bivoltine for CB11.

Another finding which is in contradiction with the empirical regularities in agricultural technology diffusion is with respect to the availability of family labour. It is generally held that the high yielding varieties are labour demanding hence labour shortage can lead to non adoption. Our study results indicate a significant negative relationship between family labour availability and bivoltine hybrid adoption decision. Our analysis in chapter 4 has indicated that the bivoltine adoption is favoured by the higher income groups as compared to the low income group. The probit regression also revealed that farm size has a significant positive impact on BV adoption. This implies that bivoltine sericulture is practiced with hired labour rather than family labour. Our field survey revealed that latest labour saving technology adoption which was originally developed for BV hybrids is complete in the area fully adopted by CB rearers also. This has considerably brought down the labour requirement. However due to the non uniform growth and maturation of the CB worms the cocoon spinning days get extended increasing labour requirement. Thus farmers are of the opinion that CB rearing demands more labour. Thus risk averter farmers who can effectively utilize their family labour tend to adopt CB.

Credit availed for sericulture, as hypothesized has a significant positive influence on BV adoption decision as given by model 1. Availing credit is thus indicative of the farmer’s capacity to execute collateral security and his inclination to be innovative. The farmers who has availed credit for sericulture would be able to invest on the infrastructure required for bivoltine rearing which increases the chances of adoption of BV hybrid technology. The importance of credit as a supply side factor also reveals its policy implications.

Contrary to our expectations the number of extension contacts with the government extension agency has not produced any significant impact on BV adoption decision. However this result is in accordance with the finding that government intervention in diffusion process rarely speed diffusion and public enterprises move slower than private owned. (Hann & Mc Dowell 1984, Rose & Joskow 1990). This may be indicative of the inefficiency of extension system which fails to create the desired impact on the mindset of the farmer regarding BV adoption.

Extension support from private Chawky Rearing Center supplying CB worms is found to have a significant negative impact on BV adoption decision. This is in accordance with our hypothesis. It is evident that the private CRCs do a lot of promotional efforts to

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11 This finding is in line with the finding of Griliches (1957) that economic incentive is the primary determinant of diffusion.

12 These are subscription to Chawky Rearing Centers, Two time feeding, Shoot rearing and use of hormones to speed up maturation of larvae reducing the period of operations by 4 to 5 days.
popularize the CB hybrids in the production of which majority of them are involved. Personal interview with farmers also revealed that the private CRCs regularly visit the crop and give guidelines for proper crop raising. In case of a severe crop loss they even replace the batch free of cost.

Government subsidy for sericulture has a significant positive impact on BV adoption decision. This indicates that the probability of continuing BV adoption is more with farmers who have received subsidy. It is to be noted that to become eligible for subsidy the farmers need to satisfy a number of conditions stipulated by the government in which separate, scientific rearing house and HYV mulberry garden are included. It can be deduced that government subsidy is a motivating factor for bivoltine hybrid adoption.

Summary and conclusion

Our analysis of the adoption process of bivoltine hybrid silkworm provides a few empirical facts. In agreement with the empirical literature on adoption, age and education are found to impact negatively on bivoltine adoption decision. So also farm size exerts a positive influence. Mitigation of perceived risk and uncertainty are found to be important on adoption of bivoltine hybrid. While family labour availability discouraged bivoltine adoption, credit encouraged it. The importance of profitability is emphasised by the results. The three variables capturing reduction in profitability of bivoltine sericulture showed significant negative influence on its adoption; however the linkage between productivity and adoption could not be explained due to data constraints. From the supply side while subsidies appear to be an encouraging factor for bivoltine adoption the extension efforts of private CRCs (supplying cross breed worms) is found to deter the choice of bivoltine hybrid by the farmer. The extension efforts of the government agencies are found to be insignificant in this respect.

Policy implications

From the above results we may be able to precise a broad direction of policy. The results stress the necessity of economic incentives on the successful diffusion of bivoltine hybrid. The probable factors determining the economic incentive to bivoltine hybrid rearing are crop stability, yield, and a suitable price differential with cross breed cocoon. It is seen that crop failures are rampant in bivoltine which affect profitability. It is also shown by our study that the average yield realized at the farmer level is far lower to that demonstrated at laboratory level or produced under expert supervision. This indicates the necessity for evolving more hybrids resistant to diseases (robust hybrids) which do not compromise with yield and are better suited to the location specific microclimate. Here arise a need for research aimed at developing location specific and trait specific silkworm breeds. Since crop loss is an important determinant of profitability the government should also implement a crop insurance scheme to support the farmers.

Even though our analysis indicate a price differential favoring bivoltine cocoon, the farmers complained during the interview that the price differential of bivoltine is narrow and sometimes prices even fall below that of cross breed (during rainy season when cocoon quality goes down). This is partly due to the fact that the reelers are hesitant to offer a higher price for bivoltine cocoon because of low prices experienced by the reeling industry for their produce, which has direct bearing on diffusion of technologies in the reeling sector. The government has to take appropriate policy decisions for the technology up-gradation in the reeling sector. The government can also think of installing a price stabilization mechanism by way of support price for bivoltine cocoon, or a production incentive system for encouraging production of quality bivoltine cocoon.

The government extension system is found to be unable to create any strong influence on the adoption decision of the farmers. However the credit availability and subsidies have strong influence on bivoltine adoption decision. The government must improve its official extension system by capacity building and organize more number of mass contact programs demonstrating the benefits of the bivoltine hybrid. Since potential credit constraints could
undermine the diffusion of *bivoltine* hybrids in the country the government should facilitate credit for sericulturists on affordable collateral.

The government extension system has a lesson to learn from the private Chawky Rearing Centers in the study area. The extension efforts of the private Chawky Rearing centers are more business oriented than service oriented. However its externalities are positive to the farmers. The government should encourage production of *bivoltine* hybrid chawky worms in the private sector by way of human resources development, financial incentives for infrastructure development for quality production and credit facilities. There is need to increase the transfer of market relevant knowledge enhancing skills of the sericultural extension system. This would require action from both demand side and supply side.

**Research gaps**

The level of technology diffusion in the reeling sector could play a vital role in diffusion of *bivoltine* hybrid technology. Further, the determinants of diffusion may have ramifications into the processing industry (yarn processing to weaving) and the prevailing administrative and political set up, manifested through its policy initiatives. Nevertheless there is no empirical evidence available to support this hypothesis, as of now. Hence there is a need to assess the level of technology diffusion in silk reeling and yarn processing industries and to inquire into the determinants of the same in order to generate information useful for taking suitable policy initiatives or for rectifying existing policies towards better diffusion of *bivoltine* hybrid technology. As illustrated under the ‘Statement of problem’ section f this paper, the achievement made by Tamilnadu in diffusion of BV-hybrid technology is notable. This indicates the necessity of further investigations into how Tamilnadu has achieved this fete. A study of diffusion of BV-hybrid technology in comparison with the examples of Karanataka and the whole of the country is worth pursuing.

**Reference**


CSB (2007) Central Silk Board data base, Ministry of Textiles Government of India

CSB (2012) Central Silk Board data base, Ministry of Textiles Government of India


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13 The bulk of research in sericulture was conducted on the farm sector for evolving high yielding mulberry and silk worm hybrids and for developing appropriate agronomic packages for sericulture. Most of the research conducted in reeling sector was aimed at developing and popularizing reeling gadgets best suitable for reeling *bivoltine* cocoons (Vasumathi, 2000). But diffusion of these technologies has been slow in reeling sector, which has rendered it, incapable of processing high quality *bivoltine* hybrid cocoons into raw-silk of matching quality. Thus there is no incentive for the reeling sector to absorb the *bivoltine* hybrid cocoons at competent prices. This in turn creates a downward price shift for *bivoltine* cocoons in the market. It appears as if, the technological advancement made in the farm sector has been offset by the lack of it in the reeling sector.


World Bank (1997) Implementation Completion Report, National Sericulture Project, Report No. 17028,