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DIFFUSION OF BIVOLTINE HYBRID SILKWORM

IN INDIA

DIFFUSION OF BIVOLTINE HYBRID SILKWORM IN INDIA

Dissertation submitted in partial fulfillment of the requirements for the Degree of **Master of Philosophy** in *Applied Economics* of the Jawaharlal Nehru University

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MPhil Programme in Applied Economics
2006-2008

CENTRE FOR DEVELOPMENT STUDIES
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June, 2008

I hereby affirm that the work for this dissertation, *Diffusion of Bivoltine Hybrid Silkworm in India*, being submitted as part of the requirements of the M Phil Programme in Applied Economics of the Jawaharlal Nehru University, was carried out entirely by myself. I also affirm that it was not part of any other programme of study and has not been submitted to any other University for award of any Degree.

30.06.2008 **G. K. Rajesh**

Certified that this study is the bona fide work of G. K. Rajesh, carried out under our supervision at the Centre for Development Studies.

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Dedicated to

C. Sadasivan Nair

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Abstract of The Dissertation

Diffusion of Bivoltine Hybrid Silkworm In India

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The Indian sericulture industry is currently constrained by low productivity, price instability and import competition. These constraints stem from the poor quantitative and qualitative performance of the prevalent *Cross breed* silkworm variety. To ameliorate the *Cross breed* silkworm, superior *Bivoltine hybrids* were evolved as early as 1970s and systematic efforts to popularise it began during 1990s. But the hybrid has not diffused well. Currently the percentage of *Bivoltine hybrid* silk production in India is around 5% only. This study is an attempt to understand the various socio economic determinants of *Bivoltine hybrid* adoption decision of the Indian sericulturist. The problem is studied in the economic perspective of technology diffusion based on a primary cross sectional survey conducted at Sreerangapattanam Taluk of Mandya district, Karnataka state.

The study revealed the importance of profitability in the adoption decision and stresses the necessity to mitigate perceived risk and uncertainties regarding the *bivoltine hybrid* among farmers. The efforts from the private Chawky Rearing Centres in promoting the *Cross breed* variety is found to be an important supply side factor detrimental to the diffusion of *Bivoltine hybrid.* While subsidies enhanced the adoption process the extension efforts from the government agencies had little impact on the farmer's decision making process.

CONTENTS

List of tables

List of figures

Chapter 1
Introduction

1.1. Background

Diffusion research, for past one 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.

Agricultural production is based on biological processes. Both plant and animal commodities require the growth and reproduction of living organisms. These organisms are subject to disease and insect (pests) problems. Their growth processes are affected by differences in soil qualities, temperatures, water availability, and a number of other environmental factors. Considering these Evenson (1974) classified agricultural technology into five categories: crop-biological, animal-biological, chemical, mechanical, and managerial. The first four categories represent "embodied technology". Plant varieties embody genetic technology in the form of disease resistance, fertilizer responsiveness and other characteristics. Likewise, animals embody genetically determined characteristics of economic importance. Chemicals such as fertilizer, herbicides and growth stimulants embody chemical properties. Machines and implements embody engineering technology. Managerial technology encompasses disembodied abstract rules of production.

The relevance of the biological technology achieved prime importance ever since man devised techniques for plant and animal improvement through selective breeding. *Adaptability* and *local effectiveness* are two important aspects determining the success of any hybrid from the diffusion point of view. Like many other innovations, hybrids (plants or animals) are most efficient as elements of a production system when they have been designed for a *specific environment.* In some cases the relevant "environment" is economic, being defined by the structure of relative prices of the array of inputs used by the production system; in others, it is the physical environment to which the process required being adapted[1].

Usually a new hybrid is released along with a full package of agronomic practices which include biochemical and mechanical technologies. While considering the diffusion of hybrids three types of problems are found in the literature. *First:* some times a new hybrid may not diffuse well, in spite of genuine promotional efforts and experimentally proven records of superior yield, product quality and potential wide adaptability. *Second:* Big yield gap between what is possible and what is actually achieved on farmers' fields, mainly due to poor extension services, institutional and cultural constraints, and farmers' long attachment to traditional practices and hence limited ability and willingness to achieve full adjustment of input levels (Ali and Byerlee, 1991; Ghatak and Ingersent, 1984; Kalirajan and Shand, 2001; Pingali and Heisey, 1999). *Third:* While measures are taken to achieve a high rate of adoption of new hybrid, little or no emphasis is given to the adoption of the technological package (Kalirajan, 1991; Kalirajan and Shand, 2001; Pingali and Heisey, 1999).

The case of *Bivoltine hybrid silkworm* in Indian sericulture[2] presents a different type of problem where in the new hybrid of proven yield potential and product quality is not well diffused while the agronomic package (which embodies the

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[1] In the case of hybrid corn, Griliches (1957) noted, local variations in soil types, climate, and pests called for the suppliers of seeds to develop particular varieties that would be best suited to the requirements of farmer in the various sub-regions of the U.S., ranging southwards from Wisconsin and Iowa, to Texas and Alabama.

[2] Sericulture is an activity comprising of cultivation of mulberry leaf which is fed to silkworms which are reared to produce silk cocoons and reeling of silk (Haumappa and Erappa, 1988). A detailed description of sericulture is given in chapter III.

chemical and engineering technology) developed for it is found to be adopted and used along with the older breeds, complementing it by enhancing its performance. This situation is alarming especially when huge investments in terms of money and human effort are involved in developing the new hybrid, intensive popularization efforts are in place with subsidies installed and when the diffusion of the new hybrid is imperative for the existence of the industry as it ensure quality raw material supply.

1.2. Importance of Bivoltine[3] hybrid silkworm in Indian sericulture industry

India is a major 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 which employs nearly 56 lakhs people (Ministry of Textiles, Government of India, 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, reelers 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 (Benchamin and Giridhar, 2005).

The Indian sericulture industry is currently facing the problems of stagnation in production, low productivity, poor quality of produce, high cost of production and competition from cheap rawsilk imports. The sericulture industry is built upon two living organisms: an insect namely silkworm and its food plant namely mulberry[4].

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[3] Silkworm races are classified into *univoltines, bivoltines* and *multivoltines*, based on the number of generations each race can produce in a year. The *uni* and *bivoltines* are temperate in origin. They are producers of high quality silk but highly susceptible to disease and sensitive to temperature and other adverse circumstances. On account of their *hibernating* behavior during unfavorable climate, they are unable to produce more than one or two generations per annum. The *multivoltines* which are tropical in origin can produce several generations in a year since they do not hibernate. They are *robust* (tolerant to high temperature and diseases) but low yielders and produce comparatively low quality silk. Though by nature the bivoltines are unable to produce more than two generations in a year these breeds are manipulated to yield five to six crops per year. A detailed account on the bivoltine hybrids and their comparative advantages is given in chapter III.

[4] 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.

Thus the quality and quantity of rawsilk output are primarily dependent on the mulberry and the silkworm breeds. Almost 95% of silk produced in India is from traditional low yielding indigenous multivoltine silkworm varieties or cross breeds [5](CSB database 2007) which are relatively poor yielders. The cocoons produced by them are unsuitable for reeling in sophisticated reeling machines and the rawsilk produced from which is charecterised 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 powerloom industry is heavily dependent on imported Chinese rawsilk 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[6] (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 rawsilk is dependent on the prevailing prices of Indian rawsilk, though the causative nature of indigenous rawsilk price has not been clearly elucidated. This has affected the indigenous rawsilk 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 the 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). 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

[5] Crossbreed (CB) is a hybrid between Pure Mysore (an indegeneous 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. A comparison of performance of BV hybrids and CB is given in chapter III.

[6] 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.

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).

1.3. The issues and need for the study

The efforts to popularise Bivoltine hybrids met with limited success at the adoption level (Ramakrishnan, 2001 and Kumaresan, 2002). It is seen that at present *bivoltine* silk forms just 5% of India's domestic rawsilk production, the remaining 95% being produced from traditional inferior breeds and cross breeds (Sinha, 1989 and Kumaresan 2000). The percentage of BV hybrid silkworm eggs distributed in India during 1999-2000 was 2.5% which was increased to 4.9% in 2004-05 (Central Silk Board data base, 2007). This indicate that only around 5% 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.

Huge investments made on 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 is not subjected much to systematic economic investigation[7]. The available, limited number of studies on this topic was 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

[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"

communication of innovations. Therefore the present study approaches the problem from the perspective of economics of technology diffusion.

1.4. 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.

1.5. 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 analyzed, first by tabulating various explanatory variables in percentages against the categorical dependent variable namely 'BV hybrid adoption decision, which took either value 1 (YES) or 0 (NO). The relationship between selected explanatory variables and the BV hybrid adoption decision was analysed by estimating a probit regression model.

The major source of secondary data on India sericulture Industry was the Statistical Section of Central Silk Board (CSB), Ministry of Textiles, Government of India, Bangalore. Apart from this, data were collected from various published reports, PhD theses and conference proceedings. The production details of Sreerangapattanam Taluk were obtained from the annual reports of Technical Service Centre, Baburayana Koppal, Sreerangapattanam, Mandya district. The global production statistics were collected from the website of International sericultural Commission (ISC), Lyon, France. The export import details of various silk commodities were obtained from the UN Comtrade database. The secondary data was used for analysing the diffusion of BV hybrid sericulture in various Indian states especially Karnataka and to analyse the general sericulture scenario in the Indian as well as global contexts.

1.6. Chapter scheme

This dissertation is divided into five chapters including the introductory chapter. The second chapter gives the conceptual frame work of the study: 'economics of technology diffusion'. The third chapter gives an over view of the Indian sericulture industry, its current problems and brings out the issues addressed in the current study. The fourth chapter presents the results of the empirical study and the final chapter summarises the results and gives the policy implications of the findings.

Chapter 2
Conceptual framework

Introduction

This chapter presents the conceptual framework of the study. It begins with a short note on changes in the perception of technological change over time until the emergence of the diffusion theory. 'Diffusion' is then defined and various theories of diffusion briefly reviewed starting from the pioneering works up to the latest diffusion models, tracing the origin and development of the economic perspective on diffusion. The concept of 'adoption' is explained with special reference to agricultural technologies. Since the focus of this dissertation is the analysis of an agricultural technology namely Bivoltine silkworm hybrid, review of theoretical literature is restricted to adoption of agricultural technologies.

2.1. Changes in perception of technological change[1]

Discovery of fire and invention of wheel[2] are early examples of man's interest in technology[3]. Among classical economists Karl Marx and Adam Smith were careful observers of the process of technological change. Adam Smith in *the Wealth of nations* (1776) identified division of labor, free markets and technical change in the form of new machines as the three important causes of increasing income. Marx believed that the use of machines by the capitalist system, though allowed vast

[1]Mansfield defines technological change as 'the advance of technology, such advance often taking the form of new methods of producing existing products, new designs which enable the production of products with important new characteristics, and new techniques of organization, marketing and management.' (Mansfield, 1969)

[2] The earliest controlled use of fire seems to date to *c.* 1,420,000 years ago. Much of the modern history of technology and science can be characterized as a continual increase in the amount of energy available through fire and brought under human control. Perhaps the most important invention in human history, the wheel was essential to developing civilizations, and has remained essential to power generation, transportation, industrial manufacturing, and countless other applications (*Britannica Ready Reference*, 2008).

[3] The term 'technology' has been defined in a number of ways. While in the common man's language it is the 'practical application of knowledge' (*Britannica Ready Reference*, 2008), in the economist's view it is 'a bundle of related techniques or the systematic application of scientific knowledge to practical work' (Galbraith, 1967 as quoted by Singh etal, 1991) or 'society's pool of knowledge regarding the industrial arts' (Mansfield, 1969). A more recent definition says 'by technology is meant the goods and services produced and the means by which they are produced in a firm, an industry or an economy' (Stoneman, 2002).

increase in productivity contributed to the collapse of the system itself by increasing 'organic composition of capital' and there by a fall in rate of profit (as reported by Coombs et. al., 1987) . Apart from these exceptions the classical economists while recognizing the fundamental importance of the 'new machines' as a cause of economic growth thought that it could be taken for granted, and did not consider it necessary to be explained (Coombs et. al., 1987). In a similar vein Ricardo, in spite of being aware of the importance of technological change in the manufacturing industry did not consider the possible role of technology in improving agriculture productivity while theorizing that diminishing marginal productivity of land would result in stagnation in agricultural productivity (Sherwood, 1985). Generation of new technology was thus seen as independent of economic factors and technology was regarded as *exogenous* to the economic system. Only relatively recently this exogenous image of technological progress has started to change. Joseph Schumpeter and Simon Kuznets were among the first economists to emphasis the importance of new products as stimuli to economic growth (Coombs et. al. 1987).

The post second-world war era witnessed a renaissance of interest in growth theory and the emergence of 'new growth theory'. One of the most important aspects of the new growth theory has been 'endogenous growth models' which analyze macro economics of the growth process with an emphasis on the role played by technological change. However these models in new growth theory with the possible exceptions of Grossman and Helpman (1991), Escott (1998), assumed that new technologies coming from the R&D sector are adopted by all producers immediately and to the limit of their potential; that is the existence of a time-intensive diffusion process is not recognized (as reviewed by Stoneman, 2002)[4]. This rendered the explicit analysis of the diffusion process not only interesting but also necessary.

2.2. Diffusion

The process of technological change is understood in terms of the Schumpeterian trilogy of *Invention, Innovation and Diffusion* (Rogers; 1972, Stoneman and

[4] "Although not true for all such models, the failure to realize that adoption of new technologies takes time suggests that as yet the analysis of diffusion phenomena has not fully penetrated the psyche of the economic profession." (Stoneman, 2002)

Diederen, 1994). Mansfield defined **invention** as 'a prescription for a new product or process that was not obvious to one skilled in the relevant art at the time the idea was generated[5]'. An invention when applied for the first time is called an **innovation** (Mansfiled 1969). To be able to turn an invention into an innovation the innovator [the firm that is first to apply the invention] needs to combine several different types of knowledge, capabilities, skills and facilities, market knowledge, a well functioning distribution system, financial resources etc. (Fagerberg et.al 2002). The innovator must be willing to take the risks involved in introducing a new and untried process, good, or service. According to Mansfield, an invention has little or no economic significance until it is applied. In this sense the lag from invention to innovation is economically important as illustrated by the case of power steering (Mansfield, 1969).

Diffusion is the process by which the use of new technology spreads (Karshenas and Stoneman, 1993). Mansfield considered diffusion process essentially as a learning process which takes place among a large number of users and producers (Mansfield 1969). According to Rogers it is the process by which new ideas are communicated to the members of the social system (Rogers 1972). A more recent and encompassing definition consider diffusion process as 'the *cumulative aggregate result* of a series of *(rational) individual calculations* that weigh the *incremental benefits* of adopting a new technology against the *cost of change* in an environment characterized by *uncertainty* and by *limited information*' (Hall; 2005). Without diffusion, innovation would have little social or economic impact[6]. But diffusion is not merely the means by which innovations become useful by being spread throughout a population, it is also an intrinsic part of the innovation process, as learning, imitation, and feedback effects which arise during the spread of a new technology enhance the original innovation (Hall; 2005). A thorough understanding of the diffusion process is also essential to evaluate the socio-economic consequences of innovation activities conducted by firms and governmental

[5] According to Mansfield, invention is an activity characterized by great uncertainty and the inventor may not be characterized as an 'economic man'. Besides having economic motives, inventors invent for fun, fame and the service of man kind, and perhaps to express the instinct of workmanship or the instinct of contrivance.

[6] Stoneman and David (1986) observed that 'what determines improvements in productivity and product quality, thereby enhancing economic welfare and the competitiveness of firms and industries, is not the rate of development of new technologies but the speed and extent of their application in commercial operations'

institutions (such as funding R&D, transferring technology, launching new products or creating new processes) aimed at improving economic and social welfare. Diffusion has been identified as the most important part of innovative process of many developing countries, backward regions or technologically laggard firms in "cathing-up[7]" with the frontier counterparts (Fagerberg and Godinho, 2004).

2.2.1 Economic perspective of diffusion

Early approaches to researching the diffusion of innovations emerged from the fields of anthropology, geography, sociology, health, marketing, and communications but were consolidated into a single research tradition in the 1960s (Rogers, 2003). These diverse traditions contributed to a plethora of literature on how the characteristics of adopters, innovations, social networks and systems, and opinion leaders influence the adoption of innovations.

The earliest noteworthy economic study on diffusion was by Jerome (1934) in 'Mechanization in Industry' (as reviewed by Mansfield, 1969). His findings, based on data for twenty-three machines for periods ranging from eleven to thirty-nine years indicated that the life history of these innovations were marked by four distinct phases which he christened as *commercial trial, rapid increase in use, slackened increase* and *decline*[8].

Most of the pioneering studies of diffusion focused on agricultural technologies. Ryan and Gross (1943), in an influential study[9] that spawned an enormous diffusion literature in rural sociology, estimated that it took 14 years before hybrid seed corn was completely adopted in two Iowa communities (Munshi, 2003). The study by Ryan and Gross (1943) used a retrospective survey method to model the diffusion of hybrid corn in Iowa. They correlated 'innovativeness' (i.e., the time of adoption) with a number of variables such as the adopter's age, education, farm size, income

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[7] "Catch-up" relates to the ability of a single country to narrow the gap in productivity and income vis-à-vis a leader country, while "convergence" refers to a trend towards a reduction of the over all differences in productivity and income in the world as a whole.

[8] Jerome found that the commercial trial phase lasted for three to eleven years; rapid increase in use- four to eleven years, slackened increase phase- three to six years and the decline phase was of undefined length. (Mansfield, 1969)

[9] According to Rogers, the study by Ryan and Gross (1943), ''more than any other study, influenced the methodology, theoretical framework, and interpretations of later students in the rural sociology tradition, and in other research traditions'' (Rogers, 2003).

and access to diverse information sources. They found an S-shaped rate of adoption and that communication between previous and potential adopters was important. The influence of their study was profound especially in developing nations where, interest in studying the diffusion of innovations has been strongest in the agricultural sector (German, 2006).

In his classic 1957 study of hybrid corn, Griliches emphasized the importance of economic incentives and profitability in the adoption of new technology, and this focus has been continued in the economics literature. Griliches (1957) showed in his seminal study on adoption of hybrid corn in Iowa's different counties that three parameters of diffusion function namely the long-run upper limit of diffusion, diffusion at the start of the estimation period, and the pace of diffusion are largely affected by profitability and other economic variables. Griliches' work (1957, 1958) spawned a large body of empirical studies which confirmed his basic finding that profitability of the technology positively affect the diffusion process (Feder, Just, and Zilberman, 1985). The use of S-shaped diffusion curves, especially after Griliches (1957) introduced his economic version, has become widespread in several areas[10]. The empirical literature spawned by Griliches (1957, 1958) established stylized facts, and a parallel body of theoretical studies emerged with the goal of explaining its major findings. Mansfield (1961, 1963) and others employed formal models (till then used to depict the dynamics of epidemics) to derive the logistic diffusion formula.

However, Griliches' views were not shared universally[11]. During the early 1960s, there was a long and heated debate between Griliches and sociologists in the pages of *Rural Sociology* on the cause of technology diffusion. In this debate, the sociologists, including Everett Rogers, emphasized *characteristics of individual decision makers, the structure of networks, and interactions among decision makers*

[10] Notably in marketing literature, to depict diffusion patterns of many products, for example, consumer durables (Sunding and Zilberman, 2000)

[11] In the last foot note of his epoch making 1957 paper Griliches made this rather poignant claim, which infuriated many sociologists who were found at their wits' end: "..... In this context one may say a few words about the impact of "sociological" variables. It is my belief that in the long run, and cross-sectionally, these variables tend to cancel themselves out, leaving the economic variables as the major determinants of the pattern of technological change.... With a little ingenuity, I am sure that I can redefine 90 per cent of the "sociological" variables as economic variables." (Griliches, 1957., p. 522, footnote 45)

in regulating the speed and extent of diffusion[12]. Though Griliches ultimately acknowledged the potential importance of these sociological factors rather half heartedly[13] he stood by his profitability hypothesis (Griliches, 1962., Griliches, 1980). A look at the turn of events reveals the constructive effect of this debate which helped to clarify the role of economic and socio-cultural factors in the diffusion process[14]. In spite of (or may be thanks to) the controversy it created Griliches' work along with those of Mansfield (1961, 1968) marked the beginning of theoretical and empirical exploration of diffusion phenomena in economics (Stoneman, 2002). Mansfield (1961) reaffirmed the profitability hypothesis of Griliches in industrial economics by showing that diffusion rates of various technologies in several industries were positively related to the profitability of the new technologies. His empirical studies suggested that the differences in *adoption rates* of twelve industrial goods were almost completely accounted for by differences in relative profitability and relative cost of adopting (Mansfield, 1961, 1968).

Mansfield viewed diffusion as a process of imitation wherein contacts with others led to the spread of technology like an epidemic (Mansfield, 1961). Though Mansfield considerably improved the conceptual basis of this epidemic theory of diffusion in his later works, he has been criticized for his reliance on *awareness* and *information spreading* (Karshenas and Stoneman, 1993) and for lacking a solid microeconomic model of the behavior of the individual firm (as reviewed by Feder, Just and Zilberman, 1985).

A major aspect of the subsequent theoretical developments was their emphasis on the explicit treatment of a firm's (or consumer's) decision to adopt, without much consideration of *information spreading* or other *epidemic type forces*. As a result

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[12] See Brandner and Strauss (1959), Rogers and Eugene (1962) and Havens and Rogers (1961).

[13] Griliches in his 1980 paper as a reply to Robert Dixon's critical review of his 1957 paper wrote: "In my original paper I emphasized differences in "profitability" as the major determinant of the rate of diffusion and claimed in a final footnote that all other possible determinants such as various personal variables suggested by sociologists could be given an economic interpretation. This led to some controversy in the pages of *Rural Sociology.* If I were to rewrite it today, I would still take the same position but add "and vice versa" at the end of that footnoie." (griliches, 1980)

[14] See Brandner and Straus (1959); Griliches (1960) and Rogers and Havens (1962).

various modeling mechanisms evolved among which the three namely *rank models*[15], *stock models*[16] and *order models*[17] were of fundamental importance.

2.3. Diffusion as a process of aggregate adoption.

Adoption and diffusion are the processes governing the utilization of innovations. Rogers (1962) defines the adoption process as "the mental process an individual passes from first hearing about an innovation to final adoption". A more precise quantitative definition of adoption is given by Feder, Just and Zilberman (1985) as 'the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and its potential'. While studies of adoption behavior emphasize factors that affect if and when a particular individual will begin using an innovation, diffusion studies depict an innovation that penetrates its potential market (Sunding and Zilberman, 2000).The distinction is more practical than conceptual, since it is the microeconomic decisions by firms that drive the diffusion path. Diffusion can be interpreted as aggregate adoption.

2.4. Salient features of agricultural technology adoption.

Hayami (1974) observed that the nature of agricultural production as a biological process is different from industrial production in that it is basically conditioned by natural environments. Agricultural technologies are developed with the objective that it should be efficient in the given environmental conditions and it should be consistent with relative factor and product prices. In consequence, there is a tendency for agricultural technology to become location-specific, and its direct transfer is limited within a small area of similar environmental conditions (Hayami,

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[15] Rank models are premised on the idea that heterogeneity among firms explains observed diffusion patterns. Here the population is ranked in terms of the benefits from adoption of a technology. It is also called probit model because of its affinity to other probit models used in economic literature such as models of unemployment. It is built upon rational profit maximizing or utility maximizing behavior. It includes an explicit theory of technique choice. These models are not self propagating. At each point in time there is an *equilibrium number of owners* or *level of use* of new technology. Over time *exogenous factors* change the equilibrium and trace out the diffusion path. (David, 1969; Davies, 1979; and Ireland and Stoneman, 1986.

[16] Stock models are built around the idea that the net return on adoption for any firm depends on the total stock of firms that have adopted, with the net return on adoption declining as the stock increases (e.g., Reinganum, 1981; Quirmbach, 1986). That is the profitability of adoption is determined by the number of other users of the technology.

[17] Order models are premised on the idea that the order in which firms adopt the new technology determines the net return that they obtain from it, with earlier adopters obtaining higher net returns (e.g., Ireland and Stoneman, 1985; and Fundenberg and Tirole, 1985). The position in the order of adoption is important because for any given cost of acquisition only firms down to some point in that order will find adoption profitable (Stoneman, 2002).

1974). Evenson identified 'technology specificity'[18] as another unique feature of agricultural technology (Evenson, 1974). As a consequence of technology specificity, in an equilibrium state, many different techniques will be used to produce the same product.

According to Feder, Just and Zilberman (1985), farmers face several distinct technological options due to the special nature of agricultural technologies[19]. They may adopt the complete package of innovations introduced in the region or subsets of the package. In such cases, several adoption and diffusion processes may occur simultaneously.

Another distinct aspect of agricultural technology adoption is illustrated by Feder (1982) where in modern technology has two components viz. *neutral to scale* (e.g., an HYV).and *lumpy innovation* with a fixed capacity (which requires a fixed installation cost regardless of size; e.g., a tube well). The lumpy innovation is beneficial to farmers who use the traditional variety as well as to the adopters of the HYV. Thus, farmers have three packages of new technology from which to choose. They can adopt either the HYV or the lumpy innovation or they can adopt both new innovations. The final decision making of the individual farmer at any moment using various permutations and combinations of the aforesaid aspects and its socio economic determinants form the subject matter of adoption research.

2.4.1. Review of theoretical literature on agricultural technology adoption

From the sociological perspective Rogers (1995) identifies four key aspects of communication behavior that encourage the adoption of innovations: (1) greater social participation, (2) a high level of interconnectedness, (3) being more

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[18] Technology specificity means that one technique or set of techniques is economically superior to an alternative technique only over a range of climate, soil and economic characteristics. In other words, the economic value of a specific technique or set of techniques (as measured by the difference in average cost per unit of output utilizing the technique(s) and the average cost of utilizing the best alternative technique) is a function of soil, climate and economic conditions.

[19] Agricultural technologies include divisible technologies like high yielding varieties and non-divisible technologies like machinery. In most cases, agricultural technologies are introduced in packages that include several components (see Clay 1975; Mann 1978), for example, high yielding varieties (HYV), fertilizers, and corresponding land preparation practices. While the components of a package may complement each other, some of them can be adopted independently. The intensity of adoption of divisible technologies can be measured at the individual farm level as the share of the farm area utilizing the technology. The adoption decision of the non divisible technology is binary in nature (yes or no).

cosmopolitan and 4) opinion leadership. Social capital[20] has usually been linked to information diffusion (Narayan, 1997; Collier, 1998; Isham, 2000).), leading to a growing interest in social capital as a means of facilitating the adoption of new technologies. However, the quantum of literature which has included such social factors in the econometric models of technology adoption is limited, perhaps because they are not easily measured

The early economic modeling of the 1970s emphasized the impact of information and knowledge on the adoption process and the time lag between awareness and actual adoption (Kislev and Shchori-Bachrach, 1973; Hiebert, 1974).

Differences in adoption rates were also attributed to endogenous factors such as differences in skills (Kislev and Shchori Bachrach, 1973), risk aversion (Hiebert, 1974) and prior beliefs (Feder and O'Mara, 1982). In the case of risk neutrality, differences in the adoption rates were attributed to differences in prior beliefs about the new technology (Feder and O'Mara, 1981).

The stock of information on a technology was recognized to be a determinant of agricultural technology diffusion (Hiebert, 1974). The probability of adoption was expected to increases as the stock of information pertaining to modern production increases say, through extension efforts.

The relationship between relative risk aversion and income was hypothesized to be a determinant of agricultural technology adoption (Feder, 1980). Just and Zilberman (1983) showed that the intensity of modern technology use depended on whether the modern inputs are risk reducing or risk increasing and on whether relative risk aversion is increasing or decreasing.

Farm size is understood as a determinant of technology adoption. Farm size is considered as a surrogate for a large number of factors such as access to credit, capacity to bear risk, access to inputs, wealth, and access to information (Feder, 1980; Feder and O'Mara, 1981; Just and Zilberman, 1983). However a number of theoretical studies show that variable inputs' use could be higher on smaller farms even when uncertainty prevails (Srinivasan 1972).

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[20] Social capital is defined as "a set of informal values or norms shared among members of a group that permits cooperation among them". According to this definition, the *mutual values* found among people in organizations foster networks that have the potential to address social problems better than could independent action (Rivera and Rogers, 2006)

Credit constraint has been identified as an impediment to technology adoption in developing economies (Feder et al., 1985). Farmers will allocate land to the new technology up to the point where credit is binding and this will result in partial adoption.

Labour availability or constraint is identified to be an important variable determining new technology adoption decision (Feder, Just and Zilberman, 1985). HYV technology generally requires more labor inputs, so labor shortages may prevent adoption. Moreover, new technologies may increase the seasonal demand of labor, so that adoption is less attractive for those with limited family labor or those operating in areas with less access to labor markets. On the other hand uncertainty regarding the availability of labor in peak seasons can explain adoption of new laborsaving technology (Feder, Just and Zilberman, 1985).

Another factor found to be influencing farmers' adoption decision of new technologies is the presence or absence of tenacy. According to Feder et.al. (1985), the results are rather conflicting. While some people argue that tenants had a lower tendency to adopt HYVs than owners (Parthasarathy and Prasad, 1978). Feder et.al. (1985) cites studies referring to HYV wheat adoption in India to show that tenants are not only as innovative as landowners but sometimes used more fertilizer per hectare than did owners.

2.5. Summary and conclusion

From the theoretical literature it is understood that the concept of diffusion of technologies has attained a very important position in the economic discipline within a very short span of time. This is not only because it is interesting to study but also because of its prominent role in the economic prosperity of any society. Adoption is the fundamental process underlying the diffusion of any new technology. Diffusion research on agricultural technology has tended to concentrate more on the adoption aspect due to its 'location specific' and 'technology specific' nature.

The economic perspective of farm level technology adoption recognize lack of credit, limited access to information, aversion to risk, inadequate farm size , inadequate incentives associated with farm tenure arrangements, labour availability or constraint, etc. as various economic factors influencing the adoption decision. In the next chapter we shall review the Indian sericulture industry in detail as a prelude to analyze the diffusion process of bivoltine hybrid technology.

Chapter 3
Indian Sericulture Industry – An Over View

Introduction

This chapter presents the background of the study describing the problems faced by the Indian sericulture industry and brings out the central focus of the study namely slow diffusion of Bivoltine hybrids. It starts with a brief note on silk and its uniqueness as a textile fibre, followed by an account on Sericulture and its socio economic significance in the Indian context. After taking a glimpse on the history of its origin and global spread, the current status of Indian sericulture is assessed. An assessment of the country's performance in the global silk trade as well as an analysis of the demand supply gap in the domestic market is undertaken. The impact of cheap imports on the domestic sericulture and silk reeling industry is also analyzed to arrive at the reasons for the dismal performance of Indian silk. In the concluding part importance of the Bivoltine Hybrid silkworm on the qualitative and quantitative improvement of Indian silk industry is discussed.

3.1. Silk

Silk is produced by an insect[1] the silkworm. It has four distinct stages in its life cycle namely *egg, larva, pupa* and *moth,* of which the pupal stage is sedentary and vulnerable to predators and inclement environment. Silk is a protein[2] secreted by the silkworm for making a protective shell around itself during pupal stage. The pupa within its silken shell together is called *cocoon.* In natural conditions a moth eventually breaks through the cocoon. Under sericultural conditions however the larva is killed in the cocoon stage itself by steam or hot air before it could metamorphose into adult moth (Federico, 1997). Prolonged cooking softens the sericin so that the filament can be unwound through a process called 'reeling'.

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[1] Silk is secreted by different species of insects. The major ones are mulberry silkworm (*Bombyx mori.*), Muga silk worm, Tasar silkworm and Eri silkworm. Mulberry silk which is accountable for 95% of world natural silk production is the most well known and universally acknowledged (Naik and Babu, 1993). The remaining three varieties are collectively termed 'non mulberry silk' or 'wild silk'. India is home for all the four varieties of silk. However the present study is restricted to mulberry silk alone and the term silk is used here to denote mulberry silk only.

[2] Silk is composed of two proteins. A fibrous protein named *fibroin* and a gummy protein called *sericin.* From the two silk glands of the mature worm, two fibres (*bave*) are secreted which are cemented together by sericin. The proteins secreted in liquid form harden upon contact with air, into a single filament. With this continuous filament, the worm spins a cocoon around itself prior to pupation (Krishnaswami et.al., 1973).

Silk is the longest continuous natural textile fibre, measuring 300 to 1500 metres in length. As a single filament is too thin for human use, several filaments are reeled together with a slight twist. This filature process is then repeated by twisting several strands into a thread of yarn, a process called "throwing". The product at this stage is called "raw silk" and still contains the gum 'sericin' which will be removed only in the yarn or fabric stage by boiling in soap and water. This process called 'degumming' gives silk the soft and lustrous quality (UN, 1994).

Silk has many unique properties which make it attractive as a textile fibre. Apart from its strength (greater than a steel wire of similar dimensions), it resists breakage, and can be streached to more than 20% of its original length. It is lower in density than cotton, wool and rayon, and is highly moisture absorbent. After degumming, it has excellent dyeing properties and assumes a lustrous, semi-transparent sheen with a smooth surface that does not soil easily. It is more heat-resistant than wool. The fabric has excellent wrapping qualities and a good 'fall' which gives it an agreeable look on the wearer's body (Currie, 1997)

3.2. Sericulture and its socio economic importance

Sericulture is an activity comprising of cultivation of *mulberry*[3] leaf which is fed to silkworms which are reared to produce silk cocoons and reeling of silk (Hanumappa and Erappa, 1988). Figure 3.1 gives the share of various textile fibres in world production. Silk has a miniscule percentage of the global textile fibre market, less than 0.2%.

This figure can be an under estimate since the actual trading value of silk and silk products is much more impressive. The unit price for raw silk is roughly twenty times that of raw cotton. The annual turnover of the China National Silk Import and Export Corporation alone is US$ 2–2.5 billion (ITC Silk review, 2001).

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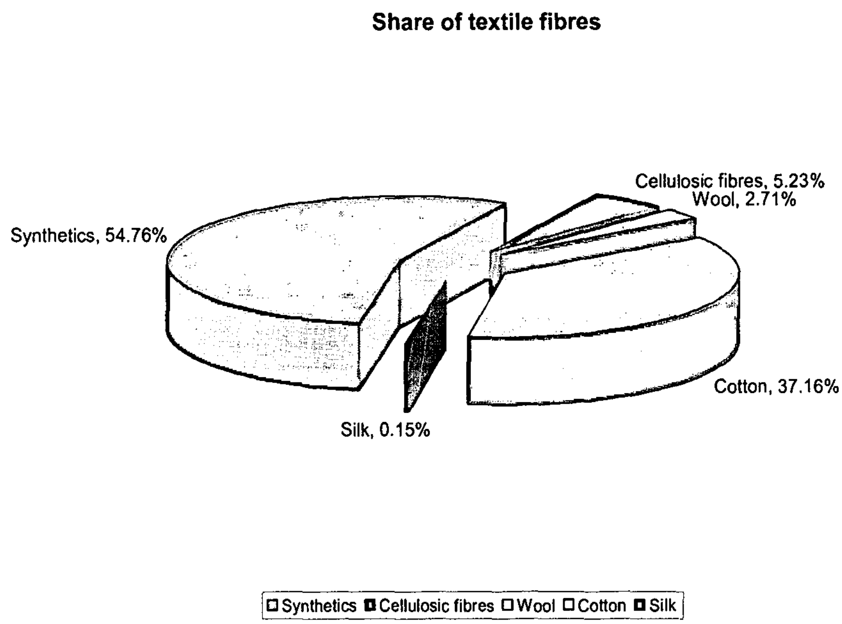
[3] Mulberry is the food plant of the silkworm, *Bombyx mori.* Mulberry leaf is its sole feed. Mulberry is a perennial tree found in tropical and temperate zones. For sericultural purpose it is generally grown as bush by frequent training. The chores of preparing silkworm diet through cultivation, harvesting, cutting and chopping leaves renders sericulture a highly labour absorbing occupation. The cost of production of mulberry leaf accounts for approximately 60% of silk production cost (Nanavaty, 1990)

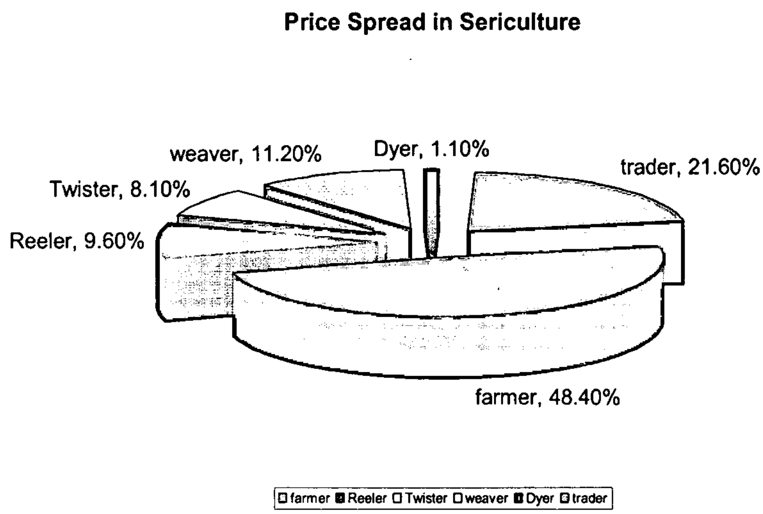
Fig.3. 1 Share of various textile fibres (in tons) in total global production in 1990



Source: United Nations (1994)

Sericulture has important socio-cultural implications. Studies have established large scale employment generation potential and high income generation potential of sericulture (Hanumappa, 1986). Jayaram et.al (1988) showed that every acre of sericulture practiced under irrigated conditions had a potential to employ 247 men and 193 women round the year. (Jayaram et.al; 1998). They have also shown that the small scale mulberry farms provided ample scope for employment of owned family labour and suggested its potential to solve the problem of seasonal unemployment. Lakshmanan et.al; (1999) found that female labour is quite dominant in all sericultural activities, to an extent of nearly 50%. Saraswathi and Sumangala (2001) observed that in the indoor activity of silkworm rearing women participation was as high as 94.67 % and that except for the peak period the entire sericultural activity is conducted using family labour. Most of the activities in silk production are in the informal sector and menial in nature. Thus about 90% of the employment goes either to the landless or to the marginal farming families that hire out these labour, or to the sericulture families (Sinha, 1989). While considering the price spread in the whole industry, it can be seen that 48% of it goes to farming sector, as illustrated in fig.3. 2

Fig.3. 2



Source: Mattigatti (2000)

Sericulture and silk production are labour-intensive at the village level, employing both men and women at all stages of production[4]. In China, it occupies some 20 million farmers, as well as 5 lakh people in the silk processing industry (ITC silk review 2001). In India, sericulture is a cottage industry in 59,000 villages,

[4] While considering patterns of location of sericulture, Federico (1997) observed, "....... . the ideal environment for silkworm raising was densely populated area, with dispersed dwellings and few opportunities for non-agricultural work. It is not surprising that sericulture did not develop at all where the population was scarce and labour, expensive (as in the United States) or where people lived in large villages far from the fields (as in the interior of Sicily or Spain)........Silkworm raising does not need strength but does require much care and caution in handling the worms, which are exteremely delicate animals, very sensitive to any form of ill-treatment and /or sudden change of temperature. Therefore sericulture was traditionally women's work, while men cultivated the mulberry trees and some times helped to transport the leaves."

providing full and part-time employment to some six million people from the farm sector, and silk processing industry (ITC silk review 2001).

3.3. Origin and spread of sericulture

The mysterious origin of silk gives it an image of mythical proportions. Its history is equally important as its physical properties in exciting human imagination to such levels no other textile fiber can rival. It is generally held that the art of silk making originated in China in 2640 BC during the reign of Shi Huang Ti, the "Yellow Emepror" (UN, 1994). Though the Chinese kept the secret for centuries, doing a brisk silk trade with the rest of the world, it was leaked out to Korea in 1200 BC. Consequent to Japanese invasion of Korea in 3rd century BC, under the reign of emperor Ninken, sericulture spread to Japan (Nanavaty, 1990). The literature is highly divided as to whether India invented the art independently or acquired from China. According to western historians, mulberry culture spread to India by about 140 BC (Nanavaty, 1990). However there is historical evidence that the art of silk production was known to Indians as early as 2000 BC. The mentions of silk in ancient scriptures such as *Rigveda, Manusmriti, Mahabharatha* and *Ramayana* testify this (Gopal L, 1961).

For many centuries the silk trade was confined to Asia. By 126 BC silks from China and India were carried to Europe by the *Silk Road*[5]. Another lesser known trade route originated from India by the 2nd century BC lasting 700 years, through which Indian silks from the Malabar Coast were shipped through the Arabian and Red seas to Myos Hormus, a port on the Gulf of Suez, and onward to Alexandria, Rome and Byzantium (Present Istanbul) (UN, 1994).

The first mention of silk in western literature is by Aristotle about sericulture in Greece during 5th century BC (UN, 1994). Emperor Justinian during 6th century BC employed two Persian monks to smuggle out silkworm eggs and mulberry seeds to Constantinople (Present Istanbul and ancient Byzantium). Subsequent to Italian invasion of Constantinople in 947 AD, sericulture spread to Italy. Italy became and remained the hub of European sericulture for nearly 300 years. By 1480 AD,

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[5] This 6,400-km road started in Xian, China, followed the Great wall to the northwest, climbed the Pamir Mountains., crossed Afghanistan, and went on to the eastern Mediterranean Sea, where goods were taken by boat to Rome. Silk was carried westward, while wool, gold, and silver were carried eastward. With the fall of Rome, the route became unsafe; it was revived under the Mongols, and Marco Polo used it in the 13th century (*Britannica Ready Reference*, 2008).

sericulture spread from Italy to France, where silk industry prospered under royal patronage which lasted until it was wiped out by 'pebrine' disease in 1865 (Nanavaty, 1990). After the fall of Byzantium in 1453 when trade along the Silk Road ceased, the Western Europe became dependent on shipments from the Far East and India, especially after the British colonization of India during 1700s (UN, 1994). In England, sericulture was introduced by King James I (1603–25), who promoted it zealously. Until the opening of the Suez Canal in 1869 London was the distributing centre for Eastern raw silks in Europe, but with the changing of the sea route came the decline in the importance of London as a silk centre in favour of Marseilles and later Lyons and Milan (Rawlley, 1919). America too had a stint with sericulture from 1522 to 1800 in various states Mexico, Virginia, Georgia and Connecticut, with varying degrees of success (Nanavaty, 1990).

Two major reasons are cited for the decline of sericulture and silk industry in Europe. One was the emergence of high-speed power looms in textile weaving, which required yarns of greater quantity, higher tensility and greater length than what the indigenous growers could offer. Secondly since the turn of the century better quality Japanese silk exports reached Europe in steadily growing volumes at lower prices, and not even protectionist tariff barriers could stem this flow (Rawlley, 1919). The great Depression of 1929 intensified the demise of European sericultural activity (UN, 1994).

When the world began to emerge from the great depression Japan accounted for over 75% of aggregate output followed by China and India. (Lockwood, 1936). The Second World War destroyed the sericulture industry in both Japan and China. From **table 3.1**, it can be seen that the silk output levels of Japan in 1970 had fallen below 50% of that of its own pre-war production which has clearly reflected on the world silk production by lowering it from 57530 tons (of 1938) to 44180 tons. Rapid industrialization, urbanization and the consequent decline in relative wages in the rural sector might have contributed to the downfall in Japanese silk production subsequently (United Nations 1994). It is seen that the decline in Japan continued ever since China, South Korea and North Korea improved production by exploiting the export potentials and employing rural labour effectively (Nanavaty, 1990).

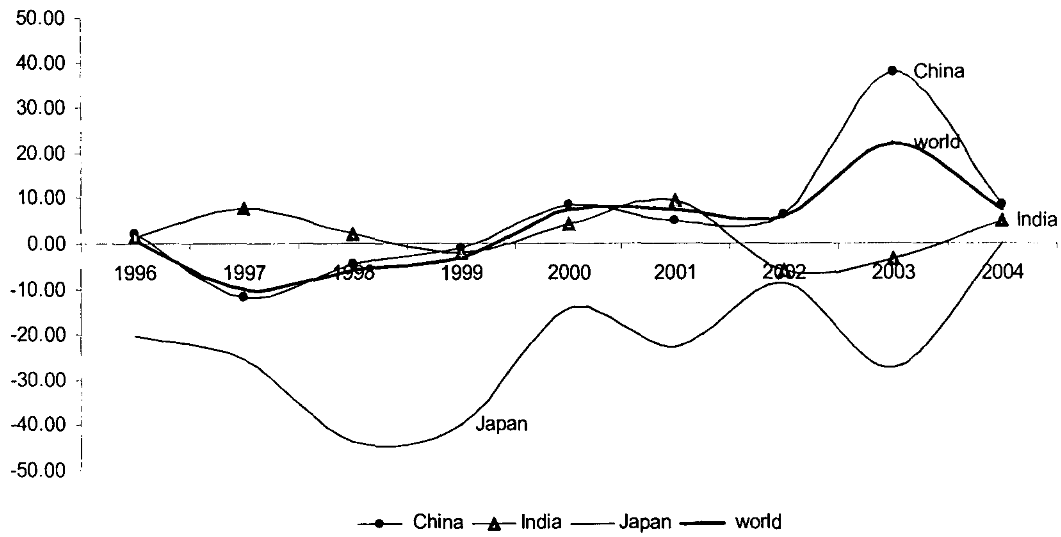
Table 3.1. Rawsilk production (in tons) in selected countries in pre and post world war periods.

	1938	1970	1980	1985	1987	1989	1990	1992	1995	2000	2003	2004
Brazil	na	na	na	na	na	na	na	na	2468	1389	1563	1512
China	4860	11120	37200	38960	40100	37944	50047	56800	67113	61648	94600	102560
India	1900	2260	2610	4900	8020	9720	10400	13200	13909	15857	15742	16500
Iran	300	400	270	280	280	460	540	550	na	na	na	na
Japan	43150	20520	15640	9590	7850	6080	5700	5070	3240	557	287	287
Korea S.	1820		2100	3500	1430	1380	4400	880				
Korea N.	1820	3020	3310	1440	na	na	1100	na	946	165	150	150
Thailand	1100	1700	890	1140	1150	1300	1350	1400	1313	955	1500	1420
Uzbekistan	na	na	na	na	na	na	na	na	1320	1100	950	950
Vietnam	500	300	280	330	360	400	510	750	2100	780	750	750
Others	2080	4860	5290	7510	11550	13980	9947	14093	2967	1952	1500	1500
Total	**57530**	**44180**	**67590**	**67650**	**70740**	**71264**	**83994**	**92743**	**95376**	**84403**	**117042**	**125629**

* figure for the year 2006, **figure for the year 2001; na- not available Source:1938 to 1992- United Nations (1994) ; remaining :Ministry of textiles, Government Of India (2004)

Table 3.1 shows that China produced more than twice the Japanese silk production in 1980 and has retained its position as the worlds largest silk producer ever since. India came to the second position in 1987, crossing Japan and retained the position there after but a long way behind China. India increased its output from 9720 tons in 1989 to 13200 tons by 1992, an increase of 3480 tons which represented a very high growth. However since 1992 India's silk production exhibited a low growth rate.

Figure. 3.3. Country wise growth rate of rawsilk production



Source: Ministry of Textiles, Government of India, 2004

Figure 3.3 illustrates the annual growth rate in raw silk production in physical quantity since 1995 in China, Japan and India as compared with the world output. It appears that the Chinese growth rate determined the growth rate of world silk output. The lines representing China and World are almost undistinguished till 2002, from which year China showed a very high growth rate of 37.9% though it subsequently fell. Though Japan has been showing negative growth in silk production through out the period, Japanese silk production has started growing recently. According to Currie (2005) this is not because of increase is sericultural production but due to the Japanese policy to import cocoon to keep the reeling plants in the country active[6]. It can be seen that India's growth rate was comparatively better than that of China and world until 1999. After 2001 it fell far below showing negative growth up to -6 % (2002) though started showing signs of recovery during 2004. Over all it appears that the fall in Indian rawsilk production has been utilized by China to increase its supply. Thinking in the reverse order probably the

[6] According to Currie (2005) "In Japanese psyche silk plays a very, very important part. It is part of the fabric of Japanese society. ....many Japanese Prime ministers have come from sericultural families. So the Japanese heavily subsidized sericulture to keep it going artificially, when economically, it ought to have disappeared".

fall in Chinese rawsilk imports subsequent to hike in Chinese production during 2002-03 could have lead to the tremendous decline in Indian silk production during that period.

3.4. Sericulture in India and its current status.

The silk trade flourished in India during the mideval period. Under the Moughals, silks from Kashmir and Bengal were exported mainly by the Moors, who during the 14th and 15th centuries transmitted it to Europe (Nanavaty, 1990). The British had identified the qualitative shortcoming with Indian silk and tried to improve it by bringing experts to mordenise the rearing and reeling techniques. In 1771, the 'China worm' was introduced with the idea of improving cocoon quality. The government promoted the extension of land under sericulture. Rent was slashed by half for those lands, and that too was exempt for the first two years of cultivation. The government also promoted a higher wage structure for processing raw silk (Ray Indrajit, 2005). Technology was substantially improved in conformity with the European know-how and practices so that British weavers accepted raw silk of Bengal. In fact, the overseas market responded very favourably to the first consignment of the new technology in 1772 (Ray Indrajit, 2005). The government was also successful in diffusing Chinese worms in sericulture. Another breakthrough was achieved in the sphere of the production system. The government successfully organized sericulture as a cottage industry. The industry's technology and organisation were thus thoroughly reformed by the close of the eighteenth century in tandem with the requirements of the European market. Consequent to the abolishment of British East India Company's monopoly on private trade the company wound up its silk trade in 1833, leaving it to private entrepreneurs. During the last quarter of 19th century Bengal silk began to decline due to lack of proper organization, husbanding authority and the absence of technical know how (Ray Indrajit, 2005).

Hanumappa and Erappa (1988) cites sericulture development in the princely state of Mysore as an example of the crucial role the state can play in augmenting the sources of rural income. Sericulture flourished in Mysore during the 18th century under Tipu Sultan. The technology was transferred from Bengal. Japanese and Italian silkworm strains were imported and experts hired from these countries (Nanavaty, 1990). Spread of diseases during 1866 and the world depression in 1929 along with competition from imported silk and rayon lead to downfall of Indian silk industry on the eve of World War II. A tariff protection commenced from 1934 to save the industry from cheap imports of silk (National Commission of Agriculture, 1976). Durng the World War II, the Indian silk industry again surged, mainly due to demand from the Allies for silk for manufacture of parachutes[7].

The first authentic enquiry into the conditions of Indian silk industry was undertaken in 1914-15 by H. Maxwell Lefroy and E. C. Ansorge (Lefroy and Ansorge, 1915). In a report they observed that the industry was scattered and unorganized producers were subjected to exploitation. They suggested formation of a central organization to address the needs of the industry (Lefroy and Ansorge, 1915). Subsequent recommendations by a Silk Panel in 1946 lead to the formation of the Central Silk Board in 1949.

Central Silk Board (CSB) is a statutory body, under the administrative control of the Ministry of Textiles, Government of India. One of the earliest commodity boards to be constituted by the Government of India, the Board coordinates the development of sericulture and advises the Government on policies governing export and import. It has the responsibility for pre-shipment inspection of silk goods exported from the country. The Board is also responsible for organizing sericultural research, training, basic seed (egg) production and collection of statistics pertaining to sericulture and silk industry (National Commission of Agriculture, 1976 and Gopalachar, 1978).

The Central Silk Board (CSB) established a number of sericulture research institutions in 1960s. With systematic efforts, it became possible in 1970s to develop a technology suitable for tropics. New mulberry varieties coupled with agronomical practices were made available to the farmers. Packages of practice were developed for silkworm rearing, besides realising new bivoltine races. Popularisation of the *bivoltine hybrids* was given priority. Since seed preparers started using bivoltine as a male parent for the preparation of cross breeds, the traditional poor yield crosses have been replaced to the extent of 85%. Consequent to this, mulberry sericulture was spread to non- traditional states like Kerala, Maharashtra, Rajasthan and Gujarat in the 1980s. While other crops (grains) perish due to very little precipitation, mulberry survives such acute situation where

[7] The industry in Mysore doubled its pre-war size. Mulberry acrage rose from 26500 to 80000. Number of filature basins in Mysore and Madras rose from 300 (in 1939) to over 2000 (in 1945). Filature silk production rose from 2300 kg(1937) to 137000 kg (1945) (Nanavaty, 1990)

ground water is also not available for raising the crops, thus providing subsistence to a large number of farmers (National Commission of Agriculture, 1976).

Currently in India mulberry silk is chiefly produced in 5 states viz. Karnataka, Andhra Pradesh , Tamilnadu , West Bengal and Jammu & Kashmir, contributing to about 99% of the total mulberry silk produced. Interestingly, the states of A.P and T.N with almost no silk production during 1960 (Vasumathi, 2000), currently occupy the second and fourth position respectively. West Bengal at present contributes about 11.8% of the total cocoon / silk production, while Karnataka contributes the lion's share (43.95%) with Andhra Pradesh and Tamilnadu contributing 38 % and 4 % respectively. Current production statistics furnished in **table.3.2**

Table.3.2. Mulberry area and cocoon production for 2005-06 in major sericultural states in India.

	Mulberry area (ha.) 2005-06	% of total	Cocoon Production 2005-06	% Of total	% contribution during 1998-99 (cocoon)
Karnataka	87734.00	49.00	55493.00	43.95	62.7
Andhra Pradesh	42458.00	23.71	48024.00	38.04	23.4
Tamilnadu	6614.00	3.69	5225.00	4.14	4.3
Jammu and Kashmir	6125.00	3.42	761.00	0.60	0.6
West Bengal	13957.00	7.79	14961.00	11.85	7.8
sub total	156888.00	87.62	124464.00	98.58	98
Others	22177.00		1797.00		
Total	**179065.00**		**126261.00**		

Source: Central Silk Board Database 2007

3.4.1. Inability to exploit export potential

Table 3.3 gives India's export, import and demand supply gap. The annual production of raw silk in India was 17305 tons, of which mulberry raw silk alone accounts for 15445 tons in 2005. The demand for raw silk was much higher than the production at 10180 tons. Hence, India imported 10538 tons of raw silk in 2005. The imports have steadily increased from 6015 tons in 2000 to 10538 tons in 2005 representing a compound annual growth rate of 9.8%, against a mere 0.25% compound growth rate in production. Over the five year period the demand supply gap has increased by 73%. The imports as a percentage of production have increased from 39% to 68%. This analysis indicate that

India has neither been able to meet the increasing demand for silk in the domestic market by increasing domestic silk production, nor to exploit the huge export potential; instead resorted to rawsilk imports to fill the domestic demand supply gap.

Table. 3.3. India's rawsilk production, export import and demand supply gap

year	Silk Prodn in tons	Export in tons	Import in tons	Demand supply gap (in tons)
2000	15214	163	6015	5852
2001	15857	513	7896	7383
2002	17351	263	10506	10243
2003	16369	384	11365	10981
2004	14620	466	10646	10180
2005	15445 (0.25%)	582 (23.63%)	10538 (9.8%)	9956 (9.26%)

Source: COMTRADE 2007. Figures in parenthesis give Compound Annual Growth Rate.

Table 3. 4 gives India's export earnings from silk (all commodities) over the period 2000 to 2005. It is seen that though the silk exports showed a compound growth rate of 7.95% over the years, its percentage share in total textile exports from the country has been stagnant over the years.

Table.3.4. India's export earnings from silk (all commodities) in million US dollars

year	Silk exports	Total textile exports	% share of silk
2000	405	6096	7
2001	530	5410.41	9
2002	495	6098.23	8
2003	474	7108.2	7
2004	605	7172.99	8
2005	641 (7.95%)	9147.78 (7%)	7

Source: COMTRADE 2007. Figures in parenthesis give Compound Annual Growth Rate.

Table 3.5 gives the value of silk and other textiles imported by India over the years. The percentage share of silk in the total textiles import has increased over the 6 years by 5.7%. Whereas the net foreign exchange earning from export and imports has remained stagnant.

Table. 3.5. India's silk imports (all silk commodities) in million US dollars

year	Silk imports	Total textile imports	% share of silk	Net foreign exchange earning
2000	126.42	1181.42	10.7	279
2001	170.9	1521.22	11.23	359
2002	195.48	1614.29	12.11	300
2003	252.29	1965.37	12.84	222
2004	304.84	2116.77	14.4	300
2005	399.64 (21.15%)	2670.75 (14.56%)	14.96 (5.74%)	241

Source: COMTRADE 2007. Figures in parenthesis give Compound Annual Growth Rate.

From the above analysis it is clear that even after being the second largest producer of silk, India contributes only 16% of global silk production and it is the largest importer of rawsilk. India has been unable to meet the increasing demand for rawsilk by the domestic industry through increasing domestic supply. This is because of two reasons namely low productivity and low quality.

3.4.2. Impact of cheap imports on domestic industry

Apart from India's inability to exploit the export potentials and dependency on imported raw material, another grave issue is pertaining to cheap imports of raw materials ruining the domestic sericulture industry. It is reported that Chinese raw silk and silk fabrics are reportedly being imported into the country at very low prices (Tikku, 1999).

The data furnished in table 3.3 reveal that the rawsilk imports to India increased from 7896 tons in 2001, to 10506 tons in 2002, which is a 33% increase in one year. During the subsequent year the domestic silk production fell by 5.6% (from 17351 tons of 2002 to 16369 tons of 2003).The domestic silk production further fell by 10% (from 16369 tons of 2003 to 14620 tons of 2004).

Table 3.6 compares the annual growth rate in rawsilk imports for five years from 2000 against the performance of Indian sericulture industry and reeling sector to generate an idea about the comparative dynamics. It is seen that the growth rate of silk imports were very high from 1999 to 2003 except for 2000-01. The growth rate in the value of imported silk (in Indian Rupee terms) has been lower than that of quantity of imports. The prices of domestic rawsilk and cocoon are observed to be worst affected during the years 2001-02 and 2002-03, the periods in which imports grew very high and prices of imported silk kept falling. Thomas et. al (2005a) showed that the cocoon price get influenced by the yarn prices with a lag of six to ten days. From the table 3.6. it is clear that during 2001-02 and 2002-03 when domestic rawsilk prices fell by 4.9% and 24.1 % respectively, the cocoon price also fell by 4.8% and 10.8%. This has impacted on cocoon production, lowering it by 8.2% and 8.4% during 2002-03 and 2003-04 respectively. The data shows that the effect of imports influenced the mulberry plantation also. During 2002-03 in Karnataka alone 23% of the existing mulberry plantations were uprooted and in the subsequent year another 10% uprooting occurred. 6780 charka reeling units have closed down over the six years where as the number of cottage basin reeling units have increased by 846 only. The number of multi end reeling units have also fallen by 59. This means considerable labour displacement from the charka sector during the six years which is not likely due to upgradation of the charka units into cottage basins.

Table. 3.6. Growth rate in rawsilk imports against performance of Indian sericulture industry.

year	Rawsilk import % growth rate		Cocoon price /kg (Rs)	Rawsilk price / kg (Rs)	Cocoon Prodn. (in tons)	Mulberry hectarge in Karnataka	Number of reeling units[8]		
	quantity	value					charka	Cottage basin	Multi end
1999-00	77.7	59.1	108.3	1015	124531	120119	34794	25785	260
2000-01	-6.1	15.1	125.9 (16.25)	1116 (9.9)	124663 (0.1)	112557 (-6.30)	35490	25988	258
2001-02	44.5	31.5	119.9 (-4.8)	1061 (-4.9)	139616 (11.9)	116158 (3.20)	32321	28051	299
2002-03	32.9	3.6	107 (-10.8)	805 (-24.1)	128181 (-8.2)	88903 (-23.46)	29733	26939	220
2003-04	2.3	-2.9	126 (17.8)	984 (22.2)	117471 (-8.4)	79778 (-10.26)	28014	26631	201
2004-05	-14.1	-3.4	114 (-9.52)	915 (-7.0)	120027 (2.2)	77998 (-2.23)	28014	26631	201

Source: Central silk Board data base. Values in parenthesis are percent growth rates.

8 The majority of silk produced in India is through charka, the traditional reeling device and less sophisticated cottage basin reeling units. Semi and fully automatic reeling machines are used to produce high quality silk in Japan, Korea and China. Multi-end reeling machines have been developed and popularized in India to produce high quality silk which need good quality cocoons of uniform size and shape as raw material.

The fall in: prices, quantity of cocoon production and mulberry area and labour displacement from the reeling sector cannot be completely attributed to the rawsilk import. Many other socio economic factors could be at play. However it is seen that subsequent to a protectionist intervention[9] of the government during 2003, the quantity of imports fell by 2.3%, domestic rawsilk prices increased from Rs. 805.00 to Rs. 984.00 per kg (22.2% growth) and cocoon prices increased by 17.8%. During the subsequent year the quantity of cocoon production showed slight improvement (2.2% growth) and the mulberry uprooting rate came down from 10.26% to 2.23%. This indicates that the silk imports have had a deleterious effect on the domestic sericulture.

Table. 3.7. Silk handlooms and power looms in India

year	Rawsilk import % growth rate		Hand looms (number)	Power looms (number)
	quantity	value		
1999-00	77.7	59.1	227701	29340
2000-01	-6.1	15.1	227701	29340
2001-02	44.5	31.5	258000	29340
2002-03	32.9	3.6	258000	29340
2003-04	2.3	-2.9	258000	29340
2004-05	-14.1	-3.4	258000	29340

Source: Central silk Board data base

It is generally held that the imported rawsilk is consumed by the powerlooms since power looms require qualitatively superior and strong yarn for the warp and the relatively poor quality local yarn is fit for the weft only (Thomas e.al, 2005b and Vasumathi, 2000). Table 3.7 gives the growth rate of rawsilk imports over 6 years from 1999-00 against number of handlooms and power looms in the country. It is seen that the number of power looms have stagnated at 29340 over the years and the number of handlooms have increased by 30299 during 2001-02. The rawsilk imports have been in the increase.

[9] Antidumping investigations were undertaken by Directorate General of Anti-Dumping and allied Duties (DGAD&AD) on a petition by the reelers affected by the falling domestic prices. The designated authority imposed antidumping duty on landed goods so as to raise import prices to US$ 27.97 per kg.on all imports of mulberry raw silk of 2A grade and below originating in or exported from Peoples Republic of China. The duty came into force wef. 3rd July 2003. (Ministry of Textiles, Government of India, 2007)

Thomas et.al. (2005b) found that only 50-53% of the yarn requirement of the power loom sector is met from Chinese imports. Thus it may be inferred that a considerable portion of the imported yarn is being absorbed by the handloom sector also, which is traditionally known as the sole consumer of charka silk (Vasumathi, 2000).

A study conducted by Thomas et.al. (2005b) revealed the pattern of rawsilk usage as given in table 3.8

Table. 3.8. Pattern of raw silk usage by power looms in Karnataka

Yarn type	% use
Chinese yarn for warp	50.52
Local BV hybrid yarn for weft	4.31
CB yarn for weft	45.16

Source: Thomas et.al. (2005b)

Thomas et.al. (2005b) also have shown that the imported Chinese silk is superior to the locally available silk with respect to denier, cleanness, cohesion, gumming losses and uniformity. Table .3.9. presents a comparison of imported silk with local silk based on these attributes.

Table.3.9. Comparison of imported and local raw silks of comparable grade

	Chinese A grade silk	Local Bivoltine A grade silk	Local Cross Breed A grade silk
Denier[10]	19.95	20.25	21.4
Cleanness	9.1	8.5	7.4
Cohesion	8.5	8	7
Winding breaks	8.5	7.75	6.53
De gumming losses	21.6	24.25	24.9
Uniformity	9.28	8.75	7.7

Source: Thomas et.al. (2005b)

[10] **Denier** - A numbering system for yarn and filament in which yarn number is equal to weight in grams per 9,000 meters of yarn. The six measures indicated in table 3.9 are the chief determinants of the quality of raw silk (Thomas et.al. 2005b)

Naik .G & Babu (1993) have estimated that the total high quality silk production in India could meet at the most 60 percent of the estimated demand and have cautioned about the negative implications of the Chinese raw silk on the development of Indian silk industry. They also noted that diversion of imported silk into domestic sector benefit only the consumer. By avoiding this diversion, the demand for domestically produced high quality silk would have increased the good health of the industry. Some of their recommendations for amelioration of the current situation include - improvement in research and extension facility, adequate supply of inputs and proper marketing facilities and modifications in the production system.

3.5. Silkworm breeds and silk quality

The best known classification of silkworm races is in terms of the number of generations that a race can live each year. Some races hatch only once a year- known as univoltine. Those hatch twice a year are bivoltines and those hatch several times are multivoltines. Uni and bivoltines thrive in the temperate zone and multivoltines thrive in the tropical zone (Vijay, 1985).

Bivoltine silk has an edge over multivoltine silk. Silk reeled from the multivoltine cocoons is very often of the 'E' grade quality compared to 'A' and 'B' grade quality silk reeled from bivoltine cocoons. Bivoltine silk is also much thicker than multivoltine silk. Fabrics made of bivoltine silk are comparatively popular throughout the world. Bivoltine cocoons also have a thicker shell and are amenable to being used in sophisticated semi-automatic reeling machines. Apart from silk quality another important factor prompting a switch over from multivoltine to bivoltine is the high productivity of bivoltine. A number of countries in the tropics are indeed making efforts at switching over from multivoltine to bivoltine (Vijay, 1985).

3.5.1. The Bivoltine hybrid silkworm

Tropical Sericultural Technology developed during 1970's helped India to increase her silk production from 969 tons (1950's) to13970 metric tones in 2003-04 (Central Silk Board data base, 2007). The major thrust of *Tropical Sericultural Technology* were introduction of bivoltine silkworm, breeding of new silkworm breeds especially suited our tropical climate and development of new rearing technology. But only 40% of the potential of bivoltine silkworms could be realized at the farmer's level. The yield gap analysis showed that in comparison to the multivoltines, the bivoltine silkworms are much less adapted to the tropical condition (Datta and Chatterjee, 1992). A breakthrough was achieved under the *Bivoltine Sericulture Technology Development Project* (1991-99), wherein many productive and qualitatively superior bivoltine hybrids[11] (BV hybrids) were developed at Central Sericultural Research and Training Institute, Mysore by utilizing Japanese commercial hybrids as breeding resource material (Datta, 2003). The concept of cross breeds (CB) is much older, which came as a means to improve local multivoltine strains by crossing with bivoltines.

Table.3.10. Comparison of bivoltine and cross breed cocoon production

Items	**BV Hybrids**		**Cross Breeds**	
	Rs / acre	**%**	**Rs / acre**	**%**
Leaf cost	27864.49	32.13	18825.83	27.31
Silkworm seed	1782.44	2.06	3766.69	5.46
Disinfectants and materials	7301.97	8.42	3755.73	5.45
Labour	13566.9	15.64	11975.61	17.37
Depreciation on fixed capital	32972.45	38.02	25485.78	36.97
Other costs	3232.12	3.73	5122.92	7.43
Total cost	86720.37	100	68932.56	100
Revenue	123519.92		86175.33	
Net return	36799.55		17242.77	
B:C ratio	1.42		1.25	

Source:Kumaresan, 2002

Table 3.10. gives comparative farm level performance of Bivoltine hybrids and Cross Breeds. It shows that the BV hybrid rearing though incur higher costs of production yield far greater profits.

[11] Bivoltine hybrid is the progeny of a cross between two bivoltine strains. Developing two parental pure lines is a pre requisite for any hybridization program. Japanese hybrids with desired traits were identified and crossed with Indian bivoltine breeds that were found good for Indian climate. Thus 18 breeds were evolved. 161 hybrids raised from promising pure lines were studied and evaluated. Out of this five were selected as promising hybrids and were authorized by Central Silk Board for commercial exploitation (Datta, 2003)

Table 3.11 compares qualitative and quantitative performance of BV hybrids and Cross Breeds. The data shows that the BV hybrids have superior qualitative and quantitative traits.

Table 3.11. Comparative performance of BV hybrids and Cross Breeds

Hybrid	Cross Breed (PM X NB_4D_2)	Bivoltine hybrid (CSR_2 X CSR_4)
Colour	Yellow	White
Silk quality[12]	B	2A to 4A
Renditta[13]	8	6
Filament length[14]	750 m.	1150 m.
Yield per 40,000 larvae	50 kg.	70 kg.
Survival %	70%	53%
Cocoon price per kg. (Rs.)	100-150	180-240

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

3.6. Efforts to popularize BV hybrids in India

The Central Silk Board, with the support of governments of traditionally multivoltine growing states of Karnataka, Andhra Pradesh, Tamil Nadu and West Bengal, introduced bivoltine during the Fifth Five-Year Plan period. The bivoltine programme, however, deviated from its objectives and bivoltine cocoons were used to produce improved crossbreed layings. However, the evolution of bivoltine breeds with a silk content of over 21-22 per cent led to a significant drop in the renditta of crossbreed cocoons from 13.2 in 1980-81 to 9.5 in 1986-87 [Mahadevappa 1987]. Intensive efforts were made to popularizing bivoltine sericulture through massive sericulture development programmes such as Intensive Sericulture Development Programme (ISDP), World Bank-assisted Karnataka Sericulture Project (KSP) and National Sericulture Project (NSP).

[12] 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.

[13] 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.

[14] Filament length is the length of the continuous filament that could be recovered from the cocoon.

The Central Silk Board obtained technical cooperation from Japanese Experts through Japan International Cooperation Agency (JICA) to develop bivoltine sericulture technologies suitable for Indian conditions during 1989, as the Japanese have the proven technologies for the production of quality silk. Bivoltine Sericulture Technology (BSTD) Project was formulated for five years from 1989, in which new bivoltine silkworm hybrids and technology packages for rearing bivoltine hybrids were evolved. The technologies evolved in BSTD Project were demonstrated and test verified with the farmers in different locations in the second phase of the project, which is known as Promotion of Popularising the Practical Bivoltine Sericulture Technology (PPPBST) Project.

In spite of these efforts the performance of bivoltine sericulture in India has been poor. The performance of the country and major silk producing states during 2004-05 is presented in table 3.12.

Table 3. 12. Cocoon production details of major sericulture states in India in 2004-05

For 2004-05	**India**	**Karnataka**	**Andhra Pradesh**	**Tamilnadu**	**West Bengal**
Total Cocoon (in in tons)	126281	54210	45453	3101	14908.
% share of state	-	42.9	36.0	2.5	11.8
CB Cocoon (in tons)	120027	50974	44403	2690	14904
BV cocoon (in tons)	6254	3236	1050	411	4.4
% state share of national BV production	-	51.7	16.8	6.6	0.1
BV seed consumption (lakh nos)		64.89	18.08	7.463	0.15
Total seed consumption (lakh nos)		1061.27	848.09	55.67	486.06
% BV adoption based on cocoon production	5.0	6.0	2.3	13.3	0.03
% BV adoption based on seed consumption		6.1	2.1	13.4	0.03

Source: Central silk Board Data base 2006

Karnataka, Andhra Pradesh West Bengal and Tamilnadu together account for 93.2% of commercial mulberry cocoon production in India. The major contributory is Karnataka state with a share of 42.9%. Karnataka's share in the total bivoltine hybrid cocoon production is 51.7%, being the largest. Percentage bivoltine hybrid cocoon production at the national level was 5% during 2004-05 which is nothing but the level of diffusion of bivoltine hybrid in the country. The maximum percentage adoption among the four states is by Tamil Nadu but the volume of production and the share in national production are low.

Figure.3.4

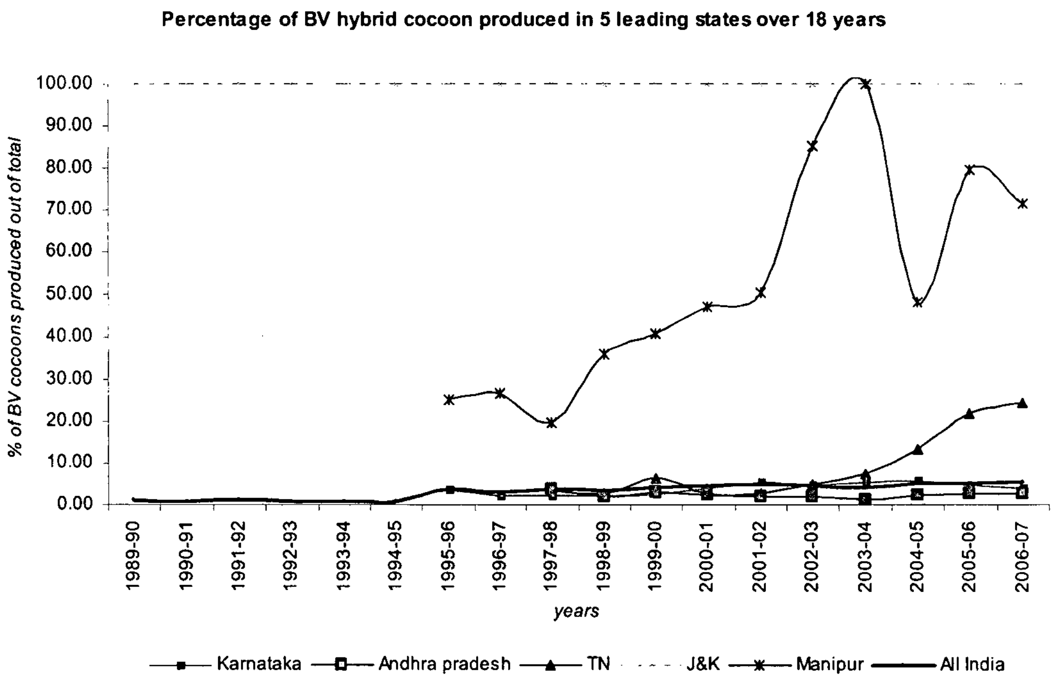


Figure.3.4. illustrates the diffusion of bivoltine hybrid in five states and in India as a whole for 18 years. Here the states with at least 5% of their total cocoon production[15] is bivoltine are selected. It is seen that the national performance, which was below 1% until 1995 has since risen but during 2006-07 remain around 5%. The Karnataka state which is the strong hold of sericulture has been able to diffuse BV hybrids to the tune of 5% only. Jammu & Kashmir, Tamilnadu and Manipur show higher diffusion rates with 100%, 24.6% and 71.5% respectively. However a closer look at the production details given in

[15] Sale of seed (silkworm egg) is the most appropriate indicator of adoption. Quantity of cocoon produced will not give the exact picture of diffusion since the cocoon production is influenced by the experience of the farmer, average yield and other factors. The decision of the farmer to adopt is first reflected in the quantity of eggs he has purchased for rearing. However here cocoon production data is taken because of data constraints regarding seed procurement.

table-3.13 shows that though J&K contributes 10.9 % of national BV production its total sericultural output (all breeds) is only 0.61% of national production. Similarly Manipur with 71% BV adoption contributes a very small portion of national cocoon production at 0.44%. The diffusion in Tamil Nadu is worth mentioning since the state has a share of 5% in national sericultural production.

Table 3.13 gives the bivoltine hybrid cocoon production details of 10 states.

Table. 3.13. Diffusion of BV hybrids in various states during 2007

States	**BV hybrid cocoon prodn (ton) 2007**	**% share in national BV Cocoon prodn.**	**% BV adoption in the region**	**% share in national cocoon prodn.**
Karnataka	2325.00	30.52	3.96	43.33
Andhra pradesh	1350.00	17.72	2.74	36.43
Tamilnadu	1924.00	25.26	24.26	5.85
Manipur	422.52	5.55	71.49	0.44
Uttaranchal	109.00	1.43	100.00	0.08
J&K	833.00	10.94	100.00	0.61
Assam	94.00	1.23	100.00	0.07
Himachal pradesh	142.00	1.86	100.00	0.10
Kerala	101.29	1.33	100.00	0.07
UP	85.23	1.12	39.87	0.16
India	7617.36	100	5.62	100

Source: Central Silk Board data base 2007.

From the table 3.13. it can be seen that five states namely Assam, Himachal Pradesh, Kerala and Uttaranchal, each with a share of around 1% of national BV cocoon production show 100% diffusion of BV hybrids. The annual cocoon production in these states is around 100 tons only and their contribution to national cocoon production (all breeds) is as low as 0.1% only. These states are non-traditional sericultural areas and therefore as part of governmental efforts to popularize bivoltine sericulture, only BV hybrid seeds are supplied by the governments. ~~From the above analysis it is clear that the adoption~~. This situation has necessitated a detailed inquiry into the factors determining adoption and diffusion of Bivoltine hybrid technology in India.

3.7. Summary and conclusion

Inspite of its small volume in global textile production, silk has importance in developing economies primarily because of its favorable socio economic consequences. The development of sericulture had been the states priority in every country. Poor productivity, poor quality, high cost of production and labour intensity are hall marks of Indian silk industry. With the advent of sophisticated power looms and relaxation in exim policies large quantities of high quality silk is imported at prices lower to local silk. This has disrupted the domestic silk reeling industry and sericulture farm sector, leading to considerable labour displacement, though protectionist government intervention has temporarily eased the problem. However unless the product quality is improved the domestic sericulture can't be protected in the long run. Popularisation of Bivoltine Hybrid silkworms is the only solution to ameliorate the qualitative and quantitative problems of Indian silk. It is seen that in spite of the governmental efforts on R&D and extension the current level of Bivoltine Hybrid adoption in the country is around 5% only. Against this background the next chapter examines the factors determining the adoption of bivoltine hybrid silkworm.

Chapter 4

Adoption of Bivoltine Hybrid: Analysis of its determinants

Introduction

This chapter empirically examines the determinants of farmer's bivoltine hybrid technology adoption. Based on the review of theoretical literature in chapter two, the various factors known to be influencing the technology adoption decision of the farmer are identified and hypotheses for the study are drawn. The chapter is organized in six sections. In the first section the various factors determining agricultural technology adoption as given by the theory are discussed. The empirical model for the study is discussed in the second section, followed by the details of the data under section three. The fourth section deliberates variable definition and construction and the fifth section gives the summary measures of the variables. We estimate the model in the sixth section and the last section summarises.

4.1. Factors determining adoption

The conceptual frame work of the study was described in chapter 2, which was based on a survey of the theoretical literature on diffusion and adoption. There exists a large number of empirical literature analyzing observed adoption patterns mostly by focusing on the relationships of key variables to adoption behavior which reveal the present state of knowledge about the adoption process. These empirical results, apart from being useful in drawing suitable policies to ameliorate the slow diffusion of innovations can open new avenues of conceptual work either by confirming or by rejecting some of the theoretical explanations in specific cases.

Recent diffusion research considers that diffusion should be modelled as a process of supply and demand interaction (Stoneman and Ireland, 1983). From a brief review of empirical literature, the following variables are found to be influencing the decision of farmers regarding adoption of bivoltine hybrid technology which can be categorized into demand side and supply side factors.

a. Age

Age of the farmer is found to be an important characteristic by Shetty (1966) and Subrahmaniam et.al. (1982). Among the different age groups it was the middle age group which showed greater tendency to adopt recommended farming practices. Added to their lack of experience, young people are not in a position to take decision in the presence of the older people.

Bivoltine hybrid rearing technology being more sophisticated, it is more likely that relatively young farmers adopt it rather than older farmers who are more traditional and security conscious, avert to take the risk of adopting the innovation.

b. Social participation.

Rogers (1995) identified four key aspects of communication behavior that encourage the adoption of innovation, namely greater social participation, high level of inter connectedness, being more cosmopolitan and opinion leadership. Social capital has usually been linked to information diffusion (Narayan, 1997 and Collier, 1998). Social participation is also an important means to aquire latest information on innovations. Thus farmers with more social participation[1] may adopt BV hybrids faster than those with lesser or no social participation.

c. Farm Size

According to Feder, Just and Zilberman (1985) The relationship of farm size to adoption depends on such factors as fixed adoption costs, risk preferences, human capital, credit constraints, labor requirements, tenure arrangements, and so on . Binswanger (1978) have found a strong positive relationship between farm size and adoption of tractor power in south Asia. Parthasarathy and Prasad (1978) found a significant positive relationship between size and HYV seed adoption in an Andhra-Pradesh village in 1971-72. Thus, the majority of evidence indicates that the incidence of adoption of HYVs is positively related to farm size[2].

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[1] The social participation is measured by asking the farmers 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 associations or any other organizations. One mark was assigned to each participation event

[2] However a number of empirical studies have shown that farm size is not an exclusive determinant of adoption of improved technology. Zeller et al. (1997) found that households with small farm sizes and low risk-bearing ability are able to adopt capital intensive crops, such as hybrid maize and tobacco if policies improve their access to credit, extension, input, and output markets. Matuschke et.al. (2007) who studied the impact of hybrid wheat in India found that neither farm size nor the subsistence level influences the adoption decision, but access to information and credit did.

d. Relative importance of the enterprise.

The relative importance of a particular crop with in the farmer's enterprise was first used as a variable for diffusion research by Griliches (1957). A case of relative importance of maize in farmer's total land holding determining adoption level of new technologies is discussed by Zeller et.al. (1997) and Sain and Martinez (1999).

e. Profitability.

The role of economic incentives and profitability in hybrid adoption decision by farmers has been established by Grilliches himself and many economists who followed. (Grilliches, 1957, 1958, 1962).

f. Risk and Uncertainty

The empirical investigations on risk and uncertainty are rare due to the difficulty in measurement. Feder, Just and Zilberman (1985) had opined that more exposure to information through various communication channels reduces subjective uncertainty. On this ground they have cited proxy variables to represent risk bearing capacity of farmers, such as 'whether the farmer was visited by extension agents' or 'whether he attended demonstrations organized by the extension service or other agencies.

In the diffusion literature 'experience' is considered as an important determinant of adoption and diffusion. The accumulation of experience of an innovation is found to have positive externalities on its adoption as the experience gained by the early adopters affects the perceptions of other farmers (Feder and Omara, 1981). As more experience is gained uncertainty regarding the performance of the innovation is reduced. Some authors showed that the efficiency of a new technology increases with experience (learning by doing) (Black man, 1999). The profit differential often will increase with experience because of learning by using; that is farmers will get more yield and save cost with more experience in the use of the new technology[3].

g. Education

Sidhu (1976) who studied the factors determining agricultural yields in the early stages of the Green Revolution in the Punjab found that farmers' education has some positive effect on yields. However According to Feder, Just and Zilberman (1985) Formal schooling play a more important role in determining allocative ability than

[3] According to Sunding and Zilberman, 'especially when it comes to new, untested technologies, elements of learning-by-doing and experience may improve the profitability of those technologies that have some environmental benefits so that farmers recognize their economic advantages. Thus, the adoption of such technologies may persist in the long run' (Sunding and Zilberman, 2000).

worker ability. Lin (1991) studied the role of education in adoption of hybrid rice in China and found that a household head's education has positive and statistically significant effects on the household's probability and intensity of adopting hybrid seed.

h. Labour availability

Hicks and Johnson (1974) have found that higher rural labor supply leads to greater adoption of labor-intensive rice varieties in Taiwan, and Harriss (1972) has found that shortages of family labor explain non adoption of HYVs in India.

i. Credit

A number of studies have found that lack of credit significantly limit adoption of HYV technology. Bhalla (1979) in a study of Indian agriculture reported that lack of credit was a major constraint for 48% of small farms and for only 6% of large farms. Similarly Wills (1972) have found that a majority of small farms reported shortage of funds as a major constraint on adoption of divisible technology such as fertilizer use.

4.1.2. Supply side factors.

Governments have largely attempted to speed up the diffusion of new technologies for which two routes have been used. The first is by information provision policies, e.g. the Agricultural Extension System. The second is by the use of subsidies (Stoneman and David, 1986).

a. Extension support

Grilliches (1957) in his analysis of hybrid corn diffusion suggested that the "advertising" activities of the extension agencies and private seed companies could have influenced the rate of acceptance of hybrid corn in the United States. Feder (1980) found that better information dissemination regarding new technologies through extension agents can reduce the level of subjective uncertainty, and increase adoption of agricultural innovations. Jamison and Lau (1982) analyzed adoption of chemical inputs in Thailand and found similar positive relationship between the likelihood of adoption and extension activity. Munshi (2004) supports this by the example of the Training and Visit extension system in India which was key to diffusion of the high yielding wheat varieties. Feder (1980) suggested that a reduction in uncertainty through extension services can even circumvent a binding credit constraint and will induce higher adoption of farm technologies. Thus the credit constraint and will induce higher adoption of farm technologies. Thus the extension efforts from the supply side is expected to create a positive influence on hybrid adoption.

c. Government subsidy

Pedersen (1970) found that government support guarantees, loans, or subsidies reduce threshold levels of acceptance of innovations. According to Feder and Omara (1981) subsidies restricted to small farmers reduce the fixed-cost element associated with non adoption of technologies. Though they support giving subsidy to early innovators for enhancing adoption, they are apprehensive about the possibility that the early adopters happen to be the higher income farmers temporarily worsening income distribution. Feder (1982) says that when credit is not a constraint, variable input subsidies will enhance per hectare application of inputs. However under credit constraint it may not work. At the same time output price subsidies may reduce the per hectare intensity of variable input use with effective credit constraint. However when credit is scarce subsidies will stimulate adoption of the scale neutral innovations while discouraging the lumpy ones. It is expected that the influence of subsidies on technology adoption is positive.

4.2. Empirical model

We use econometric methodology to examine the impact of the above mentioned variables on the probability of adoption of bivoltine hybrid. As our dependent variable is a categorical variable taking value one if the farmer adopted the bivoltine hybrid otherwise zero, we use a probit regression model. So also the cumulative standard normal curve used by probit as a transform, display an S-shaped curve.

The probability that farmer 'i' adopts bivoltine hybrid is modeled as a function facet of explanatory variable X as given below

$$P(Y_i = 1 \mid X_i) = \Phi(X_i' b) \quad \text{.................[1]}$$

Where X_i contain variables related to farmer 'i'. Φ is the cumulative standard normal probability distribution function.

A cross sectional survey was conducted from 20.11.2007 to 05.12.2007.The location for the survey was Nerellikkere and Tadagavadi ranges of Sreerangapattanam taluk of Mandya district, Karnataka.

Karnataka state was selected considering its status as the major contributory to total as well as bivoltine cocoon production in the country. Also with respect to the percentage of bivoltine adoption the state closely resembles the national scene. Mandya district was chosen for the survey considering a) mulberry cultivation under irrigated condition which reduces bias due to the constraint of rainfed sericulture on adoption decision and b) higher average yields of the district indicating higher rates of technology adoption. The sample survey was conducted in Nerellikkere and Tadagavadi ranges of Sreerangapattanam taluk considering the large number of both BV and CB sericulturists available in the area which offered sufficient variability among the farmers and the contiguity of farms making the survey easier. The convenience for travel also was considered. A detailed account substantiating the selection criteria of the study area is furnished in the appendix to this chapter.

In the Nerellikkere and Tadagavadi ranges of Sreerangapattanam taluk, there are 665 farmers spread over 22 villages. The list of farmers was obtained from the Technical Service Center (TSC) Baburayana Koppal[4]. Out of the list, 71 farmers were selected at random and interviewed using a pre tested schedule. Personal interview method was used.

4.4. Variable definition and construction

The depended variable namely the bivoltine adoption decision and the various explanatory variables are defined below.

a. Adoption status

From the data collected the respondents were categorized into 'adopters' and 'non-adopters' using the annual silkworm egg[5] consumption data. As per recommented

[4] TSC at Baburayana koppal is the office of the Assistant Director Sericulture, Department of Sericulture, Karnataka State, who coordinates the sericultural extension activities in Sreerangapattanam taluk.

[5] Almost all farmers in the sample purchased 10 to 12 days aged young worms instead of eggs. These worms are called chawky worms. 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. This not only ensures a better

practice the bivoltine hybrid is to be reared for six months from September to February (Dandin et. al., 2005). Thus all farmers are required to rear cross breed in some of their batches. Since the majority respondents have consumed both Bivoltine hybrid and Cross breed eggs 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.

b. Age of the farmer

The age of the farmer is in years as reported by the farmer, notated as ***'Age'***

c. Social participation of the farmer

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 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. This variable is notated as ***'Soc part'***

d. Farm Size

Two variables were used to capture the effect of farm size on adoption decision. Size *of total land holding* indicated by ***'Land Tot'*** represents the total land area owned by the farmer.

Ratio of annual intake of silkworm eggs to mulberry acreage [***'Ra egg-mulb'***] is the ratio of total silkworm eggs or Chawky reared worms[6] (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.

e. Relative importance of the enterprise.

Ratio of mulberry acreage to total land holding is used as a proxy for the relative importance attached by the farmer to sericulture. When the relative importance of

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crop but also saves time of farmer, permitting him to take more number of crops round the year. Here the term egg is used to denote both eggs as well as chawky reared worms.

[6] 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.

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. Here the total landholding is inclusive of own and leased land. This variable is represented as ***'Ra Mulb-Tot'***

f. Profitability.

Three variables were used to represent profitability viz. profitability through productivity, comparative profitability of bivoltine and profitability of cross breed respectively.

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.

*Difference in annual average yield between CB and bivoltine hybrid [**Diff av yld CB-BV**]* is calculated by subtracting the yield per 100 layings[7] obtained by the farmer for bivoltine hybrid from that of cross breed, during the previous year. This in case of the farmers rearing both the breeds gives the yield difference and hence comparative profitability of the two breeds at the farmer's level. 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 CB[8] as compared to BV.

*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 because, the increase in this value is indicative of an increase in the maximum price received for CB cocoon.

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[7] 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.

[8] 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.

g. Risk and Uncertainty

Two variables were used to proxy factors reducing perceived risk and uncertainty regarding bivoltine adoption.

The *number of mass contact programs attended by the farmer* [***Mass contact 0/1***] This is a categorical variable indicating whether the farmer has participated in any mass contact programs such as sericulture krishimela, exhibition, field day etc. if yes the variable took the value '1' otherwise '0'. Participation in such programs exposes the farmer to more information regarding the hybrid. Thus the proxy variable namely number of mass contacts may positively influence his BV adoption decision by reducing uncertainty and his perceived risk.

Sericulture experience [***Exp***] gives the total sericulture experience of the farmer in years. 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.

h. Education level

The *level of education* of the farmer was recorded in number of years of formal education received by the farmer starting from '0' for the uneducated. The notation ***Edn*** is used to denote this variable. It is assumed that with increasing *levels of education* the tendency to adopt BV hybrid increase

i. Labour availability

Labour availability to the farmer is captured in the variable as the *family labour* available in the household denoted by ***Fam lab***. The farmer was asked how many members of the family actively participate in the farm operations namely mulberry cultivation and silkworm rearing. Only the number of hands with considerable participation is counted and recorded. The bivoltine silkworms require comparatively more food, more space and need more attention by way of frequent cleaning, disinfection of the rearing premises etc. Thus it is expected that bivoltine silkworm rearing is more labour oriented than CB rearing. Studies by Lakshmanan et.al (2000) and Lakshmanan and Geethadevi (2005) support this view. The farmers faced with shortage of family labour may thus refrain from bivoltine adoption since hiring labour will increase cost of production. Thus it is assumed that availability of family labour will encourage farmer to adopt bivoltine hybrid.

j. Credit

To determine the role of credit as a demand side factor the categorical variable *credit availed by the farmer for sericulture* [***Credit 0/1***] is used. The farmer was asked whether he/ she has/ had availed any credit from any agency for the purpose of sericulture. The answer in affirmative was marked '1'otherwise '0'. Farmers who avail credit for sericulture are able to invest on the infrastructure required for bivoltine rearing. Thus availing credit facility by the farmer is expected to encourage adoption of bivoltine hybrids among farmers.

k. Extension by government agency

The farmers were asked how many times the government extension staff visited him during the period of a silkworm crop[9]. The number of times as reported by the farmer was recorded. The variable was denoted as Extn ***cont***.

The sericulture extension is done by the State sericulture department and the Central Silk Board through its research institutes. The major thrust of the government sericulture extension is popularization of bivoltine hybrids. The extension officers are expected to visit the crops periodically and give technical guidance for harvesting a healthy crop. Routine crop inspections by technical officers will create awareness among farmers on the various time and dosage bound practices to be followed like timely irrigation, fertilizer quantity and schedule, use of disinfectants etc. and reduce incidence of crop losses, building up confidence of the farmer on bivoltine hybrid. It is expected that the extension contacts from the government agencies will have a positive influence on bivoltine hybrid adoption by farmers.

l. Extension by the private CRC

The farmers were asked whether they received any extension support from the private Chawky Rearing Center. This categorical variable took value '1' for an affirmative answer and '0' otherwise. The variable was notated as ***Extn pvt CRC 0/1.***

The private Chawky Rearing Centers supply chawky reared CB worms only. Thus their extension effort is with the intension of increasing their sale of cross breed silkworms in competition with the BV hybrid. Thus the extension contacts from the

[9] A silkworm crop is usually of 23 to 25 days duration. However when the chawky reared worms are used it comes down by 10 to 12 days.

private Chawky Rearing Center are expected to have a negative impact on bivoltine adoption decision of the farmers.

m. Government subsidy

The farmer was asked whether he/she received any subsidy for sericulture from the government as cash. Here the subsidies as kind such as disinfection chemicals, small implements etc were not considered because though all these subsidies as kind are meant for bivoltine sericulturists, all farmers receive them. The variable is represented as **Subsidy 0/1.** Being a categorical variable it took value '1' for answer 'yes' and '0' otherwise.

Government subsidies include free supply of inputs such as chemicals for disinfection, certain useful implements, cash subsidies for construction of silkworm rearing houses and infrastructure etc. All the government subsidies are restricted for bivoltine sericulturists with the intension of promoting bivoltine sericulture. Thus government subsidies might positively influence adoption of bivoltine hybrid.

4.5. Summary measures of variables

As a prelude to the estimation of the model the data is subjected to a preliminary analysis by grouping the adoption percentage against a few variables which are known to be empirically regular, in order to gain insights into the data which might come in handy while analyzing the estimated results. The summary measures of six variables namely Age, Education, Social participation, Economic status and Farm size are discussed in this section.

i. Age of the farmer

Table 4.1 gives the percentage of respondents belonging to various age groups among adopters and non adopters. It can be seen that in the whole sample, 76% of the farmers fall with in the age group of 30 to 50 years. Among adopters 87.1% belong to this age group whereas among non adopters it forms only 67.55%. Out of the total sample 18.3% belong to age group 51 years and above and 5.63% belong to below 30 years categories. The percentage of farmers with age 51 years and above among adopters is only 9.7% whereas that among non adopters is 25%. Similarly percentage of younger farmers (below 30 years) is lower among adopters.

Table 4.1. Age wise grouping of adopters and non adopters of BV hybrid.

Age of farmer	% of each age group among adoption categories		
	Non adopters	Adopters	Total
Below 30 years	3 (7.5 %)	1 (3.2 %)	4 (5.63%)
30 to 40 years	14 (35 %)	13 (41.9 %)	27 (38%)
41 to 50 years	13 (32.5 %)	14 (45.2 %)	27 (38%)
51 to 60 years	7 (17.5 %)	3 (9.7 %)	10 (14.1%)
61 and above	3 (7.5 %)	0	3 (4.2%)
Total	**40 (100%)**	**31 (100%)**	**71 (100%)**

Source: Primary survey data

ii. Social participation

From the table 4.2, it is seen that 62.1% of the farmers had some social participation. Among non-adopters percentage of people without any social participation was slightly more (50%) as compared with that among adopters (45.2%). Only 15% of the non adopters had participated in more than one social event. None of the non adopters participated in more than three events. Among adopters 54.8% had some kind of social participation. 25.7% of the adopters participated in more than one event and 12.8% participated in more than three events.

Table 4.2. Social participation of farmers

% participation within adoption categories			
marks	**Non adopters**	**Adopters**	**Total**
0	20 (50%)	14(45.2%)	34(47.9%)
1	14(35%)	9(29%)	23(32.4%)
2	5(12.5%)	3(9.7%)	8(11.3%)
3	1(2.5%)	1(3.2%)	2(2.8%)
4	0	2(6.4%)	2(2.8%)
5	0	1(3.2%)	1(1.4%)
7	0	1(3.2%)	1(1.4%)
Total	40(100%)	31(100%)	71(100%)

Source: Primary survey data

Two proxies viz. annual income as stated by the farmer and total land owned by the farmer are used to analyze the impact of economic status on BV hybrid adoption decision.

Table. 4.3. Grouping of farmers based on reported annual family income

% of each income group among farmer categories			
Annual income Rs.	**Non adopters**	**Adopters**	**Total**
Up to 50000 (Low)	7 (30.43)	7 (29.17)	14 (29.8)
51000 to 100000 (Middle)	10 (43.48)	9 (37.50)	19 (40.4)
Above 1 lakh (High)	6 (26.09)	8 (33.33)	14 (29.8)
Total responded	**23 (100.00)**	**24 (100.00)**	**47 (100)**
Not responded	*17.00*	*7.00*	*24*

Source: Primary survey data

The farmers were asked what was their total household income during the year 2006 (previous year). Out of the 71 respondents only 47 responded and the remaining 24 preferred not to reveal their income status. Though the farmers couldn't be expected to give exact details of their annual income we examine this aspect just to have an idea how the economic status and BV hybrid adoption are inter related, fully appreciating the potential errors in the data. The respondents were grouped into three income groups viz. Low income group (up to Rs. 50000), Middle income group (51000-100000) and higher income group (above 100000).

Table 4.3 presents grouping of adopters and non adopters into three income groups based on the annual income as reported by the respondents. From the table it can be seen that 40.4% of the respondents fall into the middle income group, the remaining equally distributed into the lower and upper categories. It is seen that among adopters the lowest representation is from the low income group (29.17%) whereas among non adopters the lowest representation was from the high income group (26.09%).

iv. Farm size

In order to analyze the impact of farm size on BV hybrid adoption decision the adopters and non adopters were grouped into three size classes of land area viz. small (up to 2.5 acres), medium (2.5 to 5 acres) and large (above 5 acres). This was considered under three categories of ownership namely A) total own and lease land, B) total own land and C) acreage under mulberry.

Table. 4.4. Grouping of adopters and non adopters into size classes of land area (figures in parenthesis give % of adoption category)

Size classess	A. Total Own and lease land (Acre)			B. Total own land (Acre)			C. Land under mulberry cultivation (Acre)		
	non adopters	adopters	Total	non adopters	adopters	total	non adopters	adopters	total
Small Up to 2.5 acre	24 (61.54)	15 (38.46)	39 (100)	25 (62.50)	15 (37.50)	40 (100)	37 (58.73)	26 (41.27)	63 100)
Medium 2.5-5 acre	10 (58.82)	7 (41.18)	17 (100)	10 (58.82)	7 (41.18)	17 (100)	2 (33.33)	4 (66.67)	6 (100)
Big Above 5 acre	6 (40.00)	9 (60.00)	15 (100)	5 (35.71)	9 (64.29)	14 (100)	1 (50.00)	1 (50.00)	2 (100)
Total	40 (56.34)	31 (43.66)	71 (100)	40 (56.34)	31 (43.66)	71 (100)	40 (56.34)	31 (43.66)	71 (100)

Source: Primary survey data

From part A of table 4.4. considering total own and lease land, it is understood that majority of small and medium farmers (61.54% & 58.82%) were non adopters while majority of the big farmers (60%) were BV hybrid adopters.

From part B of the table, considering total own land area, a similar trend was observed. From part C, considering acreage under mulberry cultivation alone it is found that while majority of small farmers (58.73%) were non adopters and majority of medium farmers (66.67%) were found to be BV hybrid adopters. The big farmers were found to be indifferent, being distributed equally between adopter and non adopter categories. This analysis reveals that with increasing size of land holding the farmers tend to adopt BV hybrids; however the mulberry area alone doesn't determine the adoption decision. While the size of the land holding can proxy the economic status of the farmer, a farmer who devotes his entire land or a considerable portion of it for sericulture and thus left devoid of any subsistence crops will consider various economic factors such as income, relative risk of crop loss, labor availability etc. while deciding on adoption of BV hybrids. This may be because in the absence of subsistence crops the impact of potential crop losses could be fatal.

v. Experience

The respondents in the current study were asked about the number of years of their experience in sericulture as well as cross breed and bivoltine rearing experience separately to have an idea about the possible influence of these variables on their bivoltine hybrid adoption decision.

Table 4.5. Grouping of adopters and non-adopters based on total sericulture experience

Sericulture Experience (years)	Adoption categories		
	Non adopters	Adopters	Total
Less than 5 years	7 (17.5%)	1 (3.2%)	8 (11.3%)
5 to 10 years	14 (35%)	9 (29%)	23 (32.4%)
11 to 20 years	13 (32.5%)	14 (45.2%)	27 (38%)
Above 20 years	6 (15%)	7 (22.6%)	13 (18.3%)
Total	**40 (100%)**	**31 (100%)**	**71 (100%)**

Source: Primary survey data

From table 4.5 it can be seen that the largest chunk of non adopters (67.5 %) fall within 5 to 20 years experience category and the smallest group under non adopter category is of veterans with more than 20 years experience. Here we can see that the non adopter category follows the pattern of the sample (given under the total column) and thus it just represents the population under experience wise stratification. But the case of adopters is different. Among adopters there is a clear majority (45.2%) which belong to the category of 11 to 20 years experience followed by those with 5-10 years experience (29%). That is 74.2% of adopters have 5 to 20 years of experience. It can also be noted that while among the non adopters the percentage of farmers with below 5 years experience and above 20 years experience are almost equal (17.5% and 15% respectively), among adopters only 3.2% were of less than 5 years experience and 22.6% had more than 20 years experience. The data shows an increasing trend of adoption with experience.

The influence of experience is further investigated by grouping the farmers based on their differential experience in rearing of BV hybrids ad Cross breed silkworms. It is seen that majority of farmers in the sample had reared BV hybrid at least once. Thus it is considered that the adoption decision of the farmer will have a strong bearing upon his own practical rearing experience with both the breeds. The table 4.6 and 4.7 present grouping of adopters and non adopters according to their rearing experience of BV hybrid and Cross breeds respectively.

Table 4.6. Grouping of adopters and non-adopters based on Bivoltine hybrid rearing experience

BV experience (years)	Adoption categories		
	Non adopters	Adopters	Total
Nil	10 (25%)	0	10 (14.1%)
Less than 5 years	14 (35%)	10 (32.3%)	24 (33.8%)
5 to 10 years	14 (35%)	19 (61.3%)	33 (46.5%)
Above 10 years	2 (5%)	2 (6.4%)	4 (5.6%)
Total	40 (100%)	31 (100%)	71 (100%)

Source: Primary survey data

From the table 4.6. on bivoltine hybrid rearing experience it can be seen that 25% of non-adopters were devoid of any bivoltine rearing experience and only 5% of the non adopters were with more than 10 years BV rearing experience. It is found that the percentage adoption increases with experience. While 32.3% of adopters were with less than five years experience the adoption level increased to 61.3% with 5-10 years experience. The non-adopters are found to be almost neutral to their bivoltine experience.

Table 4.7. Grouping of adopters and non-adopters of BV hybrid based on Cross Breed rearing experience

CB experience (years)	Non adopters	Adopters	Total
Nil	0	1 (100%)	1 (100%)
Less than 5 years	9 (90%)	1 (10%)	10 (100%)
5 to 10 years	14 (58.3%)	10 (41.7%)	24 (100%)
11 to 20 years	12 (46.2%)	14 (53.8%)	26 (100%)
More than 20 years	5 (50%)	5 (50%)	10 (100%)
Total	40 (56.3%)	31 (43.7%)	71 (100%)

Source: Primary survey data

The case of cross breed rearing experience revealed a similar but less clear picture as presented in table 4.7. (This table is to be read row wise only since percentage of adopters and non adopters are worked out separately for each experience category). With increase in CB rearing experience the bivoltine adoption also has increased. In the case of farmers with more than 20 years of CB rearing experience equivocal preference is found between CB and BV hybrids.

The above analyses indicate that experience has positive influence on the BV hybrid adoption decision of the farmers.

vi. Number of years of formal education of the farmer

In table 4.8. the farmers are grouped according to the number of years of formal education received, into five categories, viz. illiterate (cannot read and write and no formal education), those who can read or write or received any formal education up to 10th standard including 10th fail, 10th standard pass, 11th to 12th and finally graduates and above.

Table 4.8. Grouping of adopters and non adopters with respect to education

Education	% level of educated in each adoption category		
	Non adopters	Adopetrs	Total
Illiterate	15(37.5%)	14 (45.16%)	29 (40.8%)
Less than 10 yrs	17 (42.5%)	8 (25.8%)	25 (35.2%)
10th pass	5 (12.5%)	1 (3.2%)	6 (8.5%)
11-12 years	2 (5%)	7 (22.6%)	9 (12.7%)
Graduates	1 (2.5%)	1 (3.2%)	2 (2.8%)
Total	40 (100%)	31 (100%)	71 (100%)

Source: Primary survey data

From the table it can be observed that 40.8% of the farmers have not received any formal education at all and are illiterate, 35.2% received below 10 years schooling. The percentage of farmers who have received any formal education among BV adopters is 54.84% as against 62.5% among non adopters. Percentage of farmers with 10th standard pass is higher (12.5%) among non adopters than that of BV adopters (3.2%). Also 45.16% of BV hybrid adopters are illiterates whereas only 37.5% of non adopters are illiterates. However BV adopters include a higher percentage of 11-12th educated farmers (22.6%) than that of non adopters (5%). Among the adopters the percentage of graduates is also comparatively high. The results show that 25.8% of the adopters are well educated and only 7.5% of the non adopters are well educated.

vii. Profitability

Productivity plays an important role in profitability. In sericulture two major factors determining cocoon productivity is average yield which is dependent on the ability of the farmer to take successful crops. Table 4.9. gives the average yield[10] realized for CB

[10] Average yield means cocoon yield realized from 100 layings (eggs laid by 100 silk moths equalling 40000 individual eggs). Here for the study, the average yield obtained from each silkworm

and BV by the farmers in the sample. Since almost all the farmers reared CB and BV atleast once in the year, the information contains the experience of all the farmers in both breeds

Table. 4.9. Average yield of CB and BV

Yield per 100 layings in kg (Annual average)	Cross breed		Bivoltine	
	Number of farmers	%	Number of farmers	%
below 40	0	0	7	14
40-60	16	29	36	72
above 60	40	71	7	14
	56	100	50	100

Source: Primary survey data

. From the table it can be seen that 71% of the farmers reported average yield above 60kg for CB but only 14% of them reported 60kg average yield for BV. Majority (72%) of farmers, who reared BV, reported average yield between 40 kg- 60 kg and 14% of them got very poor yield of less than 40 kg. None of the farmers reported less than 40kg average yield for CB. This result shows that comparatively CB crops give better yield than BV crops. This observation is strongly in opposition with the claims in the literature on bivoltine hybrid performance, based on field trials under supervision.

Table. 4.10. Average yield of adopters and non adopters

Yield per 100 layings in kg of both breeds (Annual average)	Non adopters	Adopters
below 40	6 (15%)	11 (38%)
40-60	17 (44%)	14 (48%)
above 60	16 (41%)	4 (14%)
Total	39 (100%)	29 (100%)

Source: Primary survey data

Table 4.10 gives the annual average cocoon yield of adopters and non adopters for both BV and CB crops put together. The table indicates that a higher percentage of non adopters get better yield of 60 kg and above and a considerable number of BV adopters get very poor yield of below 40 kg per 100 layings. This indicates the better productivity level of non adopters.

crop by every farmer was collected separately for BV and CB, and the average for the year calculated for each breed for the farmer.

Table. 4.11gives an over all picture of crop failure in CB and BV. During the previous year the total crop failure in the sample was 15% (for both breeds). 70% of the total crop loss was contributed by bivoltine hybrid rearing.

Table. 4.11 Crop failure in CB and BV

	CB	**BV**	**Total**
Layings supply	55383 (53 %)	49915 (47 %)	105298 (100%)
Failure	4595 (30 %)	10890 (70 %)	15485 (15 %)

Source: Primary survey data

Table. 4.12. Percentage crop failure in BV and CB

Crop failure %	**BV** Number of farmers	**CB** Number of farmers
No failure	20 (28%)	42 (71%)
up to 10%	22 (31%)	0
11 to 50%	24 (34%)	14 (24%)
above 50%	5 (7%)	3 (5%)
	71 (100%)	59 (100%)

Source: Primary survey data

Table no 4.12 compares the percentage crop failure incidence in BV and CB rearings in the sample. Crop failure is calculated by taking the percentage of layings completely failed during the year. 71% farmers who reared CB reported 100% succees of their CB batches as against mere 28% in BV. And it is understood that crop failure is more in BV batches.

Analysis of profitability will be incomplete without an analysis of relative market prices of the two breeds of cocoon.

Table. 4.13. Average cocoon price per kg in rupees obtained by farmers

Price in Rs.	**BV- percentage of farmers**	**CB percentage of farmers**
Below 100	0	26 (44%)
100-125	15 (30%)	29 (49%)
125-150	20 (40%)	3 (5%)
above 150	15 (30%)	1 (2%)
	50 (100%)	59 (100)

Source: Primary survey data

Table. 4.13. summarises the relative prices received by the farmers for BV and CB cocoons. The farmers were asked the prices they received per kg of cocoon during the previous year against each crop for both CB and BV. From this data average price for the year for each farmer is worked out separately for the two breeds and tabulated. The table shows that the minimum price for BV is Rs.100.00 whereas 44% of the farmers got less than Rs. 100.00 for cross breed cocoon. Similarly a good number of farmers reported average price for bivoltine more than Rs. 150.00 per kg. There is a clear indication that BV cocoons fetch a better price than cross breed cocoons.

4.6. Estimation and results.

We estimate the probit model (1) using maximum likelihood method. As we are using large number of explanatory variables, putting all of them in a single regression would reduce the degrees of freedom drastically. Therefore we estimate five regression models each containing seven variables at a time. The results are reported in table. 4.14

Table.4.14. Probit regression results

Variable	Model -1	Model -2	Model -3	Model -4	Model -5
Constant	-.1316925 [-0.13]	-2.118839** [-2.62]	-.9958572 [-1.49]	-.1669868 [-0.26]	.8771456 [0.83]
Age	-.0613273* [-2.39]				
Edn	-.126698* [-2.40]	-.146846* [-2.53]			
Soc part			.0672721 [0.36]	.1294353 [0.62]	
Exp	.0462769* [2.17]	.0514218* [2.09]	.0348412 [1.46]	.069614** [2.65]	.030957 [1.08]
Fam lab				-.2817048* [-2.42]	-.4219281** [-2.56]
Land Tot	.2320935* [2.31]	.0246611 [0.24]			
Ra Mulb-Tot	2.104048** [2.64]	2.051582* [2.26]	1.734529* [2.31]		
Extn cont			.0323301 [0.34]		
CB Pmax-min			-.0220159** [-2.99]		.0045317 [0.37]
Ra egg-mulb				.001877* [2.06]	.004035** [3.26]
Ra coc-mulb				-.0043808** [-3.11]	-.0073815** [-3.25]
Diff av yld CB-BV					-.0486666** [-2.96]
Credit 0/1	.8866021* [1.94]				
Extn pvt CRC 0/1		-2.234289** [-2.88]	-1.687972* [-2.42]	-2.046914* [-2.32]	
Mass contact 0/1	1.030694* [2.28]	1.645243** [2.91]			
Subsidy 0/1		1.746456** [2.98]	1.31716** [2.67]	2.138132** [3.41]	2.20197** [2.83]
LR chisquare [Prob chisquare]	29.12 [0.0001]	39.58 [0.0000]	37.49 [0.0000]	40.73 [0.0000]	63.790 [0.000]
Pseudo R2	0.2993	0.4069	0.3853	0.4187	0.6557
No. of observations	71	71	71	71	71

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

The chi square values reported under each equation test 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. Detailed analysis of the results with respect to the explanatory variables is furnished below.

Age

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 (Dasgupta, 1987). 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. This variable was used as a proxy for the uncertainity reducing factor which will positively influence the farmers BV adoption decision by reducing uncertainty and perceived risk by aquiring more information. The variable **'experience'** is found to impact positively on bivoltine adoption decision of the farmer as given by models 1, 2,4and 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 uncertainity reduction have shown positive influence on BV adoption decision, it can be inferred that risk and uncertainity play a vital role in poor adoption and diffusion of the BV hybrid. Thus the promotional agencies should consider this aspect also.

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 discussion under summary measures indicates two crucial problems faced by bivoltine rearers namely poor average yield and crop losses. The performance of CB is far better with respect to average yield and crop success. 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.

The analysis under summary measures has indicated that the average price of BV cocoon is comparatively higher than that of CB. Thus inspite of this price differential, if the farmers tend to adopt CB more it has to be understood that the impact of other factors such as crop losses, extra investment, perceived risk and uncertainty regarding the technology play a vital role on the adoption decision of the farmer.

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 trade off 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 CB[11].

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[12] 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

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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.

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 averting 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 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.

4.7. Summary and conclusion

In this chapter we have examined the factors determining bivoltine adoption decision of the Indian farmers based on an empirical study conducted at Sreerangapattanam Taluk of Mandya district, Karnataka. The study is done through the economic perspective of technology adoption.

Out of the 16 variables tested 14 are found to have significant impact. From the demand side age and education impact negatively on bivoltine adoption decision whereas social participation does not have any influence. The variables capturing farm size as well as relative importance of sericulture have positive influence. Mitigation of perceived risk and uncertainty are found to be of significant positive influence on adoption. While family labour availability stimulated adoption of cross breed, credit encouraged bivoltine adoption. The importance of profitability is found to be impressive. 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 impact negatively on the choice of bivoltine hybrid by the farmer. The extension efforts of the government agencies are found to be insignificant in this respect.

Apendix to the chapter 4.
The study area

4.A.1. Karnataka state

Karnataka, Andhra Pradesh West Bengal and Tamilnadu together account for 93.2% of commercial mulberry cocoon production in India. The major contributory is Karnataka state with a share of 42.9%. Karnataka's share in the total bivoltine hybrid cocoon production is 51.7%, being the largest. Percentage bivoltine hybrid cocoon production at the national level was 5% of total during 2004-05. From table 3.12 (of chapter 3) it can be inferred that among the leading states, Karnataka with 6% adoption level best represents the country in bivoltine hybrid adoption and is the most ideal location for undertaking a study of determinants of bivoltine hybrid adoption by Indian farmers. Though Tamil Nadu represents a better bivoltine adoption percentage the total as well as bivoltine seed consumption volume is much smaller than that of other states.

4. A.2. Mandya district

In Karnataka, 28 districts practice sericulture. The table 4.15 presents the comparative performance of four major sericultural districts of Karnataka namely Kolar, Bangalore Rural, Mandya and Tumkur, which together account for 73.9 % of mulberry area, 80.5 % of silkworm seed intake and 88.6 % of total cocoon production of Karnataka.

Table. 4. 15. Performance of four major sericultural districts in Karnataka during 2006-07 (figures in parenthesis indicate % of total state)

Districts	Mulberry plantation (ha.)	Total seed Distribution (Lakh no.)	Total cocoon production (in ton)	Yield per 100 layings	Rawsilk prodn.(in ton)
Kolar	35373 (36.23)	411.36 (33.67)	22210 (37.84)	53.99	2975.33 (30.22)
Bangalore(R)	20298 (20.79)	404.50 (33.10)	17775(30.28)	43.94	2382.44 (37.74)
Mandya	12913 (13.22)	129.37 (10.59)	9738 (16.59)	75.27	1308.31 (16.6)
Tumkur	3579 (3.67)	38.61 (3.16)	2297 (3.91)	59.49	311.57 (3.95)
Total of 4 districts	72163 (73.91)	983.84 (80.52)	52020 (88.62)	58.1725	6977.65 (88.51)
Total Karnataka	97647 (100)	1221.92 (100.00)	58697 (100.00)	48.04	7883.00 (100)

Source: Central silk Board Data base 2007

These districts are prominent not only in quantitative terms but also productivity wise. That is, with only 73.9% of the state's mulberry area these 4 districts together produce 88.6% of cocoon and 88.5% of silk. Among the four districts Kolar accounts for 36.2% of the total mulberry plantation and 37.8% of total cocoon production of the state. Bangalore Rural district follows with 20.79% of total plantation and 30% of cocoon production. Mandya district accounts for 13.2% of mulberry area and 16.59% of cocoon production in the state. However Mandya's cocoon productivity (yield per 100 layings) is high at 75.2% as compared to 53.9% of Kolar and 43.9% of Bangalore Rural districts. This probably is indicative of a higher percentage adoption of technologies in Mandya district. Apart from the above reasons the Mandya district is selected for the current study considering the convenience to reach and find contiguous farm units with large number of both BV rearers and CB rearers providing sufficient variability in the sample.

4. A.3. Sreeranga pattanam Taluk

In order to identify the factors determining the adoption of bivoltine hybrid silkworm by farmers a field level study was conducted. Sreerangapattanam taluk of Mandya district, Karnataka was selected for the primary survey. Sreerangapattanam is a traditional sericulture area. Efforts to popularize sericulture here dates back to the regime of Tipu Sultan. Later this role was taken over by the Maharajas of Mysore and subsequently by state and Central governments. This particular area was selected for the current study on following considerations.

1. Sreerangapattanam is an important bivoltine belt. Table 4.16 shows that the percentage bivoltine adoption level in the region has increased from 10.9% to 34.6% over a period of six years. The higher percentage adoption level (as compared to the state level) ensures sufficient number of adopters and non adopters in the sample in order to undertake regression analysis on binary decision making.
2. Three important agencies viz. State Sericulture Department, Central Silk Board and Japan International Cooperation Agency (JICA) are involved in the bivoltine hybrid promotional efforts in this area. Thus it is expected that information asymmetry (regarding bivoltine hybrid) among the farmers is minimum, leaving room for more pronounced role for economic variables determining adoption decision.

3. Mandya district is one of the most well irrigated areas in Karnataka. The farmers are not constrained by water scarcity. Therefore it is considered that the hybrid adoption decision will not be biased by the problem of water scarcity, whereas in the other areas irrigation water scarcity is considered to be one of the major factors discouraging hybrid adoption.
4. Sreerangapattanam lies in close proximity with the Central Sericulture Research and Training Institute (CSR&TI), Mysore, which is the premier sericulture research station in the country. The area is covered under the Institute Village Link Program (IVLP), under which bivoltine hybrid is promoted by technological support as well as supply of inputs such as chawky reared bivoltine worms. The area also hosts a number of private Chawky Rearing Centers (CRC) which supply chawky reared cross breed worms. Almost the entire farming community subscribe to either government or private CRCs leaving only a minority of farmers who purchase silkworm seeds directly. This gives an opportunity to compare the differential influence of government and private extension efforts and marketing strategies on the adoption decision of farmers.

Table 4.16. Bivoltine hybrid adoption in Srirangapattanam Taluk

	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Number of farmers		492	510	605	625	741
Layings brushed (No.)						
CB	314748	257325	314250	308725	252190	441775
BV	38698	64050	128312	127750	171800	234150
Total	353446	321375	442562	436475	423990	675925
%BV	10.9	19.9	29.0	29.3	40.5	34.6
Cocoon produced (in ton)						
CB	155.9	128.3	150.3	157.6	138.5	237.5
BV	21.8	39.0	53.4	73.8	103.2	139.9
Total	177.7	167.3	203.6	231.3	241.7	377.4
%BV	12.3	23.3	26.2	31.9	42.7	37.1

Source: Annual report, TSC Baburayana Koppal, 2006

The study area comes under the technical supervision of Technical service Center (TSC), Baburayana Koppal, Department of sericulture, Karnataka. The TSC is headed by Assistant Director of sericulture. There are five sericulture ranges, 56 villages and 896 farmers in the area as per the details given in table 4.17.

Table 4.17. Details of sericulture farmers of Srirangapattanam taluk (2007).

Sl. No	Sericulture Ranges	No. of villages	No. of farmers
1	Kirengur	6	47
2	K Sattahally	18	123
3	Mahadevapura	10	61
4	Nerellikkere	12	415
5	Tadagavadi	10	250
	total	**56**	**896**

Source: TSC Baburayana Koppal, 2007

Out of the five ranges, Nerellikkere and Tadagavadi were selected considering the larger number of farmers available.

Table 4.18.Presents various characteristics (expressed in percentage) of the sample of 71 farmers interviewed from Nerellikkere and Tadagavadi ranges of Sreerangapattanam taluk.

Table.4.18. Techno economic characteristics of Sreerangapattanam taluk in comparison with that of Karnataka state

Values in percent	Sample (%)	Karnataka State * (%)
Literates	59.2	na
Irrigated mulberry	100	89.36
BV hybrid adoption	43.7	5.08
HYV mulberry adoption	94.4	38.5
Received any sericulture training	28.2	na
Separate rearing house	45.1	4.81
Adoption of shoot rearing technology	97.2	na
Subscription to CRC	98.6	na
Cocoon yield from 100 layings (of all breeds)	53.2	48.7
Cocoon yield from 100 layings (of BV hybrid)	44.5	37.9
Farmers with Average yield 50% and above (all breeds)	54.4	na
Farmers with Average yield 60% and above (all breeds)	35.3	na
Farmers availed credit for sericulture	25.4	na
Small farmers (up to 2ha mulberry land)**	97.2	85.3
Medium farmers (2.5 to 5 ha mulberry land)**	2.8	11
Big farmers (more than 5 ha mulberry land)**	-	3.67

Source: primary survey data, * Central silk Board Data base 2006, **Classification by Central Silk Board.

na- not available

59% of the sample was literate who have received some kind of schooling. 100% of farmers in the sample possessed either own or public irrigation facility in their mulberry garden. The percentage of irrigated mulberry in the entire Karnataka state is 89.36. In fact the entire Sreerangapattanam taluk is well irrigated round the year. While 94.4% of the sample has adopted HYV mulberry variety only 43.7% of them are BV hybrid adopters. In comparison with the state level performance of 38.5% (HYV mulberry) and 5.08% (BV hybrid) the sample performance is very high. 28.2 % of the sample has received sericulture training. Regarding technology package adoption, while 45.1% of the sample possesses separate silkworm rearing houses and 97.2% adopted shoot rearing technology 98.6% use the recommended practice of Chawky Reared silkworms instead of purchasing seeds. It is to be noted that only 4.81% of the sericulture farmers in Karnataka state possess separate rearing houses. Average cocoon yield per 100 layings (of all breeds) in the sample was 53.2% against 48.7% of the State. Similarly average cocoon yield per 100 layings of BV hybrid was 44.5% in the sample against 37.9% of the entire state. 54.4% of the sample farmers could get an average cocoon yield of 50% out of 100 layings (all breeds) whereas only 35.3% could get an average yield of 60% and above. 97% of the sample constituted small farmers and the remaining 2.8% were medium farmers. At the state level small, medium and large farmers constituted 85.3%, 11% and 3.67% respectively. This analysis indicates that the performance of sericulture with respect to various techno economic aspects in the study area is far superior to the State level performance.

The BV hybrid adoption in the study area was found to be above the national and state level adoption and technology adoption was found to be superior to the state level adoption. The study area is well irrigated and HYV mulberry adoption was found to be very high. This ensures that the farmers are not constrained by water scarcity, problems related to leaf quality and other technological constraints and it is expected that their choice of silkworm breed would be based more on socio economic factors rather than technical reasons.

Chapter. 5

Summary and Conclusion

India is the second largest silk producer in the world. However its sericulture is marked by low productivity and poor quality of produce. Because of this reason India import large quantities of rawsilk mainly to meet the demands of the high speed powerlooms. 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. It is in this context that the present study was taken up to look into the factors determining the diffusion of bivoltine hybrid silkworm in India.

The concept of diffusion of technologies has attained a very important position in the economic discipline relatively recently. Adoption is the fundamental process underlying the diffusion of a technology. Diffusion research on agricultural technology has tended to concentrate more on the adoption aspect due to its 'location specific' and 'technology specific' nature. The economic perspective of farm level technology adoption recognize economic variables such as lack of credit, limited access to information, aversion to risk, inadequate farm size , inadequate incentives associated with farm tenure arrangements, labour availability or constraint, etc. This study was undertaken in the economic perspective of technology adoption.

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.

5.1. Policy implication

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 some times 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.

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