Assessment of Technical Manpower Requirements in Agriculture Sector in India

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Abstract

The aim of this paper is to develop an integrated demand-supply model to forecast the requirements of technical manpower in the Indian agriculture sector. Technical manpower has played an important role in achieving self sufficiency in food grain production in India. At the current levels of operations itself, there is shortage of technical manpower at various levels of the agriculture sector. Drawing on system dynamics methodology, a causal model is initially developed which is subsequently transformed to a dynamic simulation model that captures the dynamics of manpower demand-supply interactions. The simulation results show technical manpower shortages in agriculture sector in India. A policy of 50 percent increase in the intake capacity of the technical institutions is proposed which is thereafter evaluated with anticipated sectoral growth rates of 3 per cent and 4 per cent respectively. The policy was found to alleviate the shortage of technical manpower substantially for both the scenarios. However, the policy makers need to make further interventions in balancing the technical manpower supply and demand in the long run.

Keywords Agriculture sector, Technical manpower, Demand-supply gap, System dynamics

Introduction

Agriculture is and continues to be one of the cornerstones of the Indian economy. It accounts for about 24 percent of India's gross domestic product (GDP) and accounts for about 52 percent of the employment in the country. It is estimated that if the country's GDP rate of over 8 percent has to be maintained, the agricultural sector has to grow at the rate of at least 4 percent (Golait, 2007; Viswanadham, 2005). In India, growth of other sectors and overall economy depends on performance of agriculture to a considerable extent. Not only it is a source of livelihood and food security for a large population of India but also has a special significance for low income, poor and vulnerable sections in the country.

Technical manpower in agriculture sector has played an important role in achieving self sufficiency in food grain production. At the current levels of operations itself, there is shortage of technical manpower at various levels of the agriculture sector. A survey by Federation of Indian Chambers of Commerce and Industry estimated a shortage of agricultural scientists to exist to the tune of 60 percent, and shortage of food safety professionals to exist to the tune of 70 percent (FCCI, 2007). There is a pressing need to address the demand-supply gap of technical manpower in agriculture sector if the country has to raise its level of processing and also to gain a sizeable share of the international trade in agricultural products and processed foods.

The purpose of this paper is to assess the requirements of technical manpower in agriculture sector in India through the development of an integrated model. A dynamic simulation model based on system dynamics methodology is developed for this purpose. The model is utilised for projecting the demand and supply of technical manpower forward to a target of twenty years in the future with anticipated additions of new degree graduates along with the subtractions out of migration. Finally, the projected supply is compared with the projected demand, and a policy is analysed to effect a balance.

The rest of the article is organized as follows. Section 2 is on the literature review. Section 3 is on developing a dynamic manpower forecasting model utilising system dynamics and discuss the base run and policy results. Finally the conclusions are laid out.

Literature Review

Manpower forecasting studies

The manpower planning process includes forecasting the future demand and supply of manpower and then developing action plans to reconcile the discrepancies between demand and supply (Kwak and Garrett, 1980; Milkovich and Boudreau, 1994). Reliable manpower demand and supply forecasts can provide a basis for making better decisions for avoiding redundant investments, achieving efficient and balanced growth of an industry, and in developing an economy (Chan et al., 2006; Kao and Lee, 1998; Kwak et al., 1977). Kao and Lee (1998) list the various forecasting techniques utilised in manpower modeling. Much of the literature on demand analysis is devoted to manpower forecasting at the micro level, while manpower forecasting at the macro level is equally important, when it comes to the economic development of a country (Kao and Lee, 1998).

Many of the previous studies focused mainly on either supply or demand forecasting of manpower. Bechet and Maki (1987), and O'Brien-Pallas et al. (2001) give the forecasting techniques used for modeling either supply or demand of manpower. Hence there is a paucity of studies that deal with a combination of the two which is known as an integrated model (Park et al., 2008). Moreover, many researchers call for the need of demand-supply integrated models. Lomas et al. (1985), O'Brien-Pallas et al. (2001), and Prescott (1991) observers that in modeling for manpower requirements, there is a need to account for all the factors that would influence the manpower supply, demand and utilisation in an industry. In short, industry level manpower forecasting is required to make decisions on alternate policies. For the same, an integrated model, considering demand and supply simultaneously is required to be developed. Previous studies on manpower forecasting at industry level includes that for health care industry (O'Brien-Pallas et al., 2001), manufacturing industry (Kao and Lee, 1998), construction industry (Chan et al., 2006) and information security industry (Park et al., 2008) to name a few.

System dynamics and manpower forecasting

System dynamics (SD), a methodology of system enquiry (Wolstenholme and Coyle 1983) is a theory of structure and behavior of systems that helps in analyzing and representing the interactions governing the dynamic behavior of complex socio-economic systems (Forrester, 1961). It can handle complex feedbacks and delays present in the system in predicting the system's behaviour over time. To develop a system dynamics model, a causal loop model (or CLD) is developed initially. Causal loop diagrams depict the causal relations that exist between the variables in a system through the use of text, arrows and symbols (Stepp et al., 2009). A causal relationship between two variables is positive if they move in the same direction and negative if they vary in the opposite direction. A causal loop is reinforcing if it have zero or an even number of negative causal relations and which result in reinforcing the behaviour of the system. A causal loop is balancing if it has odd number of negative causal relations and which stabilizes the system behaviour over time. System dynamics aids in analysing the effects of alternate policies on the system's behaviour before implementing them.

System dynamics have been used in manpower planning and forecasting studies all over the globe. Suitability of SD in manpower forecasting is cited by Jantsch (1972; 1973), Khoong (1996), and Martino (1980). Parker and Caine (1996) bring out the advantages of utilising system dynamics methodology over sophisticated mathematical modeling techniques in human resource forecasting. System dynamics was used for manpower planning and forecasting in steel plants (Roy and Koul, 2009), health services (Chung et al., 2010), enterprises (Wu et al., 2003), and information security industry (Park et al., 2008). Sterman (2002) suggested that complex systems require a mastery of concepts such as stocks and flows, feedback, delays, and non-linearity. The present study is aimed at developing a forecasting model of this kind which can incorporate the feedbacks present in the system.

Developing a dynamic manpower forecasting model

Causal loop model

Here we develop a dynamic integrated demand-supply model for manpower forecasting in agriculture sector in India. The model is built on a system dynamics framework. Initially a causal loop model (or casual loop diagram) is presented to capture the structural relationships existing between manpower supply and demand and its determinants (Figure 1). Details of causal loop model on feedback loops, loop polarity, loop name and loop components are depicted in Table I.

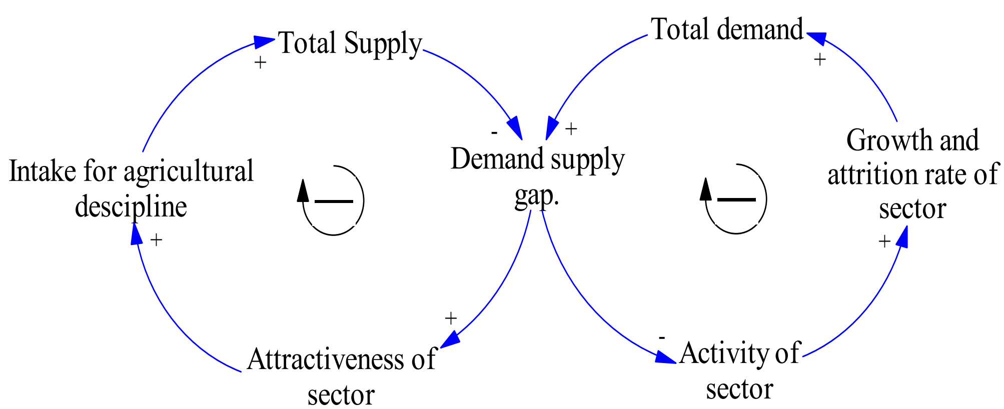

Figure 1. Causal loop diagram for the manpower forecasting model

Loop ID	Balancing (-) or reinforcing (+) loop	Loop name	Loop components
B1	Balancing	Supply enhancement loop	Total supply, Demand-supply gap, Attractiveness of sector, Intake for technical courses
B2	Balancing	Demand fulfillment loop	Total demand, Demand-supply gap, Activity of sector, Growth and attrition rate of agriculture sector

Table I. Details of causal model on feedback loops, loop polarity, loop name and loop components

The causal loop diagram in Figure 1 shows two negative feedback loops – one related to supply enhancement (loop B1) and the other related to demand fulfillment (loop B2). The ultimate goal is to create a situation where the demand and supply equilibrates. However, dynamicity of the loops creates imbalances all the time.

Agriculture manpower in India comes mainly from educational institutions (undergraduate and graduate colleges). The supply constitutes the graduating students from these colleges and universities in three categories – degree graduates, post-graduates and doctorates. The demand is generated from the attrition of currently employed stock and additional requirements due to the growth of the agriculture sector employing the graduates. Demand-supply gap affects the attractiveness of the sector which subsequently affects the intake in the technical institutes in the country and also negatively affects the central activity of the sector.

Development of the system dynamics model

Based on the causal loop model for the agriculture sector manpower supply and demand, a system dynamics model is developed for manpower forecasting needs of the sector. The dynamic model was designed and run using STELLA software, chosen for its graphic performance and the ease of comparing results. The data was collected from the reports of authorized institution of National Academy of Agricultural Research Management (NAARM). The data for supply side and demand side modeling are summarized in Table III and Table IV respectively. The growth and attrition rates were arrived on discussion with the experts. The system dynamics model is developed for degree holders, and has two major divisions. These are as follows:

1) Demand for degree holders
2) Supply of degree holders

Level	Definition
Primary	Under-graduates students.
Middle	Post-graduate students.
High	Doctoral students.

Table II. Manpower levels defined

Courses	Variable	Value
Doctorates	Current stock	38632
	Intake capacity	2320
	Migration rate	2 percent
Post-Graduate	Current stock	84482
	Intake capacity	7999
	Migration rate	2 percent
Under-Graduate	Current stock	317837
	Intake capacity	18769
	Migration rate	2 percent

Table III. Data of degree holders for supply side modeling for base year 2009-2010
Source: NAARM

Variable	Value
Degree employed	442716
Agriculture sector growth rate	4 percent
Attrition rate	2 percent

Table IV. Data for demand side modeling for base year 2009-2010
Source: NAARM

1. Demand for degree holders

The stock and flow diagram for the demand of degree holders is shown below in Figure 2.

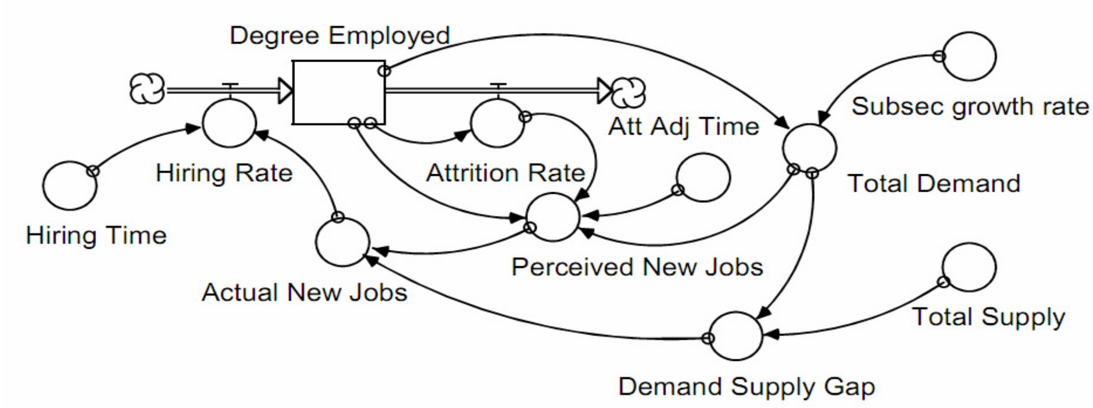

Figure 2. Demand for degree holders

As is evident from the Figure 2, the 'Hiring Rate' of the degree holders depends on 'Actual New Jobs' that are available. The 'Attrition Rate' is assumed to 2 percent per year. The 'Degree Employed' is the level variable showing the accumulations at a point of time. 'Total Demand' for the degree holders depend on the 'Degree Employed' multiplied by the (1 + 'Growth Rate'). If the 'Total Demand' is less than the 'Total Supply' for the sector, then there exists a 'Demand-supply Gap'.

2. Supply of degree holders

The stock and flow diagram for the supply of degree holders is shown below in Figure 3.

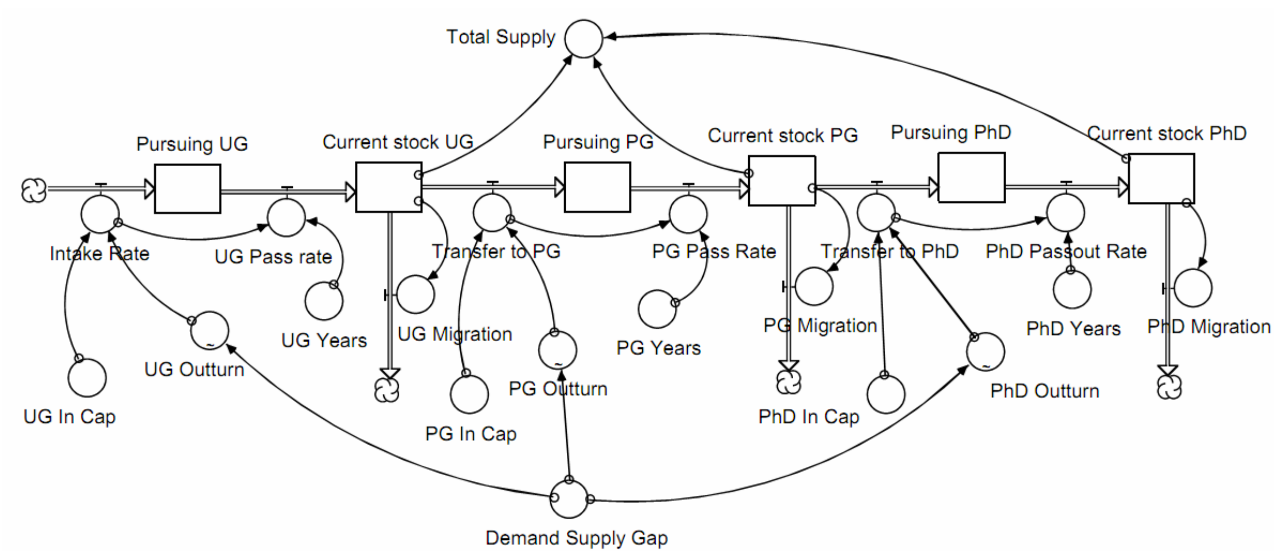

Figure 3. Supply of degree holders

The model shows that there are Intake Capacities specified for under-graduate (UG), post-graduate (PG) and doctoral (PhD) students. Out of these capacities, only a percentage of students actually pass out. The years of study is considered to be 4 years for under-graduate, 2 years for post-graduate and 3 years for doctorates. Not all UG students passing out will join for PG as some migrates to other disciplines. The migration rates are all assumed to be 2 percent per year. In case of PG and PhD, the pass-out rate depends on Transfer rate of students from other related disciplines as well. For simplicity, it is assumed that 50% seats are filled by such transfers. The students who pass out join the accumulations of 'Current Stock UG', 'Current Stock PG' and 'Current Stock PhD' respectively. When these are added together, we get the 'Total Supply' for a sector.

Base run results

The base run was realized using the data from Table III and IV. The time horizon for which the forecast was carried out is 20 years spanning from 2010 to 2030. The bases run result for degree holders are tabulated in Table V and depicted in Figure 4.

Course	**Variables**	**2010**	**2015**	**2020**	**2025**	**2030**
Degree	Supply	440951	460964	483128	503208	521673
	Demand	442716	475159	498028	519297	538829
	Demand-supply Gap	1765	14195	14900	16089	17156

Table V. Base run results of key variables

The simulation results show an excess of demand over supply for degree holders, indicating a shortage of technical manpower in the sector. The demand and supply of degree holders are increasing over time and both the demand and supply curves are moving parallel. Still the increasing supply cannot keep pace with the increasing demand creating a demand-supply gap. Moreover, the demand-supply gap shows an increased widening from 2020 to 2030 compared to that of period 2010-2020.

Hence, if the present scenario continues, it is to be expected that the demand for the degree holders will outrun their supply during the period 2020-2030 as evident from Figure 4.

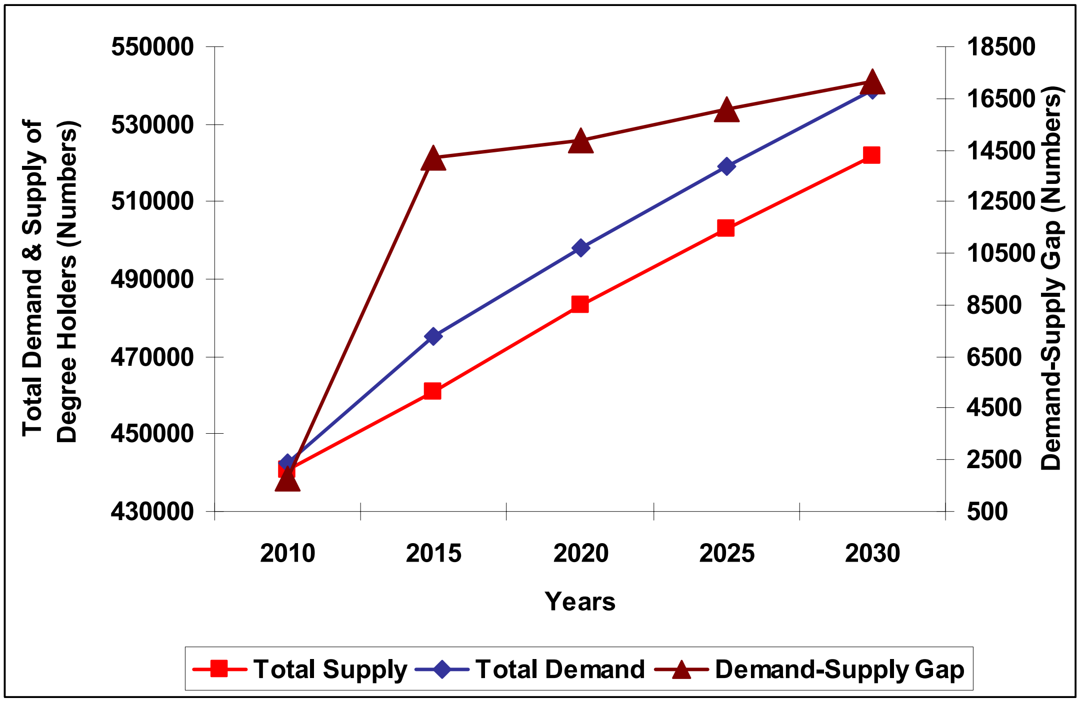

Figure 4. Agriculture sector manpower demand and supply of degree holders

The agriculture sector manpower forecast base run results for degree holders show a demand-supply gap to exist. This in turn is a clear indication of creation of more employment opportunity for degree holders in the future.

Policy analysis and outcomes

To alleviate the shortage for technical manpower, agriculture educational institutions' efforts are necessary. The efforts should be directed towards increasing the intake capacities for the degree courses, thereby increasing the supply of additional manpower to meet the high future demands. Presently the policy of a 50 percent increase in intake capacity for degree courses for two scenarios of 4 percent and 3 percent sectoral growth was analysed for its effects to balance the manpower supply and demand in the sector.

The SD model was rerun with the policy for two growth scenarios, and the results are tabulated in Table VI and depicted in Figures 5 and 6 respectively.

Policy	Variables	2010	2015	2020	2025	2030
50% increase in intake, 4% sectoral growth	***Supply***	440951	460703	516571	564268	608804
	Demand	442716	467708	526821	577131	624187
	Demand-supply Gap	1765	7005	10250	12864	15384
50% increase in intake, 3% sectoral growth	***Supply***	440951	461102	515305	561544	604537
	Demand	442716	463633	520764	569088	614111
	Demand-supply Gap	1765	2531	5459	7544	9575

Table VI. Simulation results of key variables for the adopted policy with two sectoral growth scenarios

The policy of an increase in intake capacity by 50 percent for degree holders with an anticipated sectoral growth rate of 4 percent (Table VI, Figure 5) shows some improvement over the base run results. The supply curve has moved closer to demand curve thereby reducing the demand-supply gap compared to the base run. However, the demand-supply gap continues to widen towards 2030 showing the need for further intervention in the future. The same policy of an increase in intake capacity by 50 percent for degree holders with an anticipated sectoral growth rate of 3 percent (Table VI, Figure 6) also show improvements over the base run results. Here also the supply curve has moved closer to demand curve compared to the base run. Hence, the policy of a 50 percent increase in intake capacity for the degree courses can alleviate the manpower shortages to a considerable extent in the future by reducing the demand-supply gap in both the scenarios of the sector registering either a 4 percent growth or a 3 percent growth.

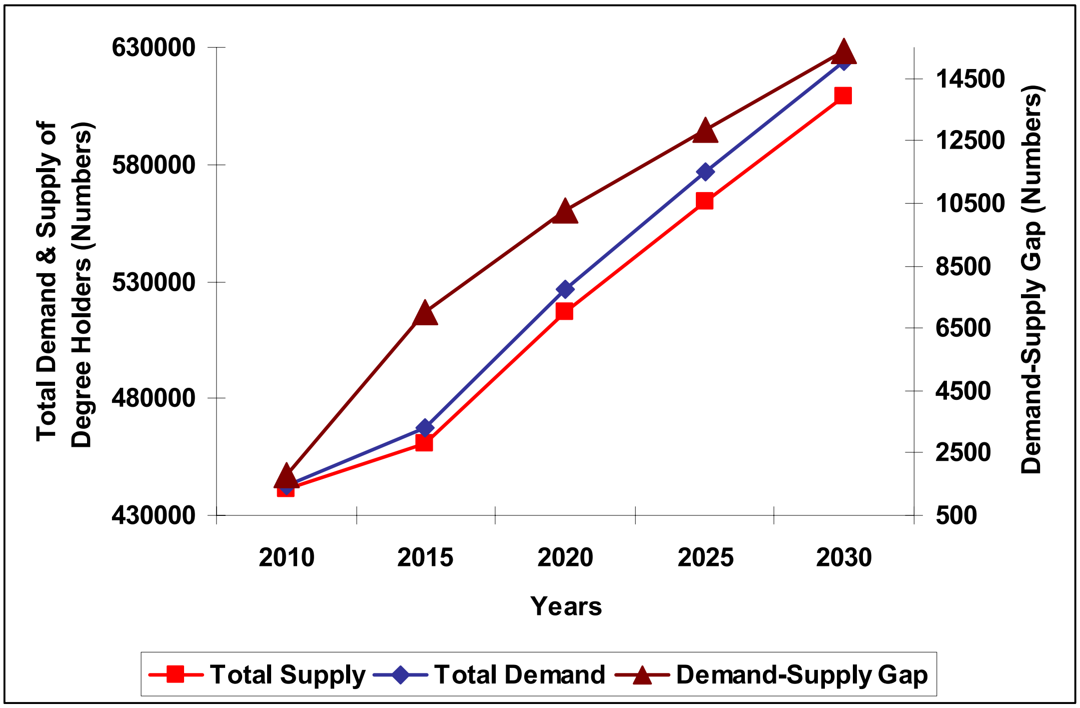

Figure 5. Overall agriculture demand-supply plot for degree holders for 50% increase in the intakes for 4% growth rate

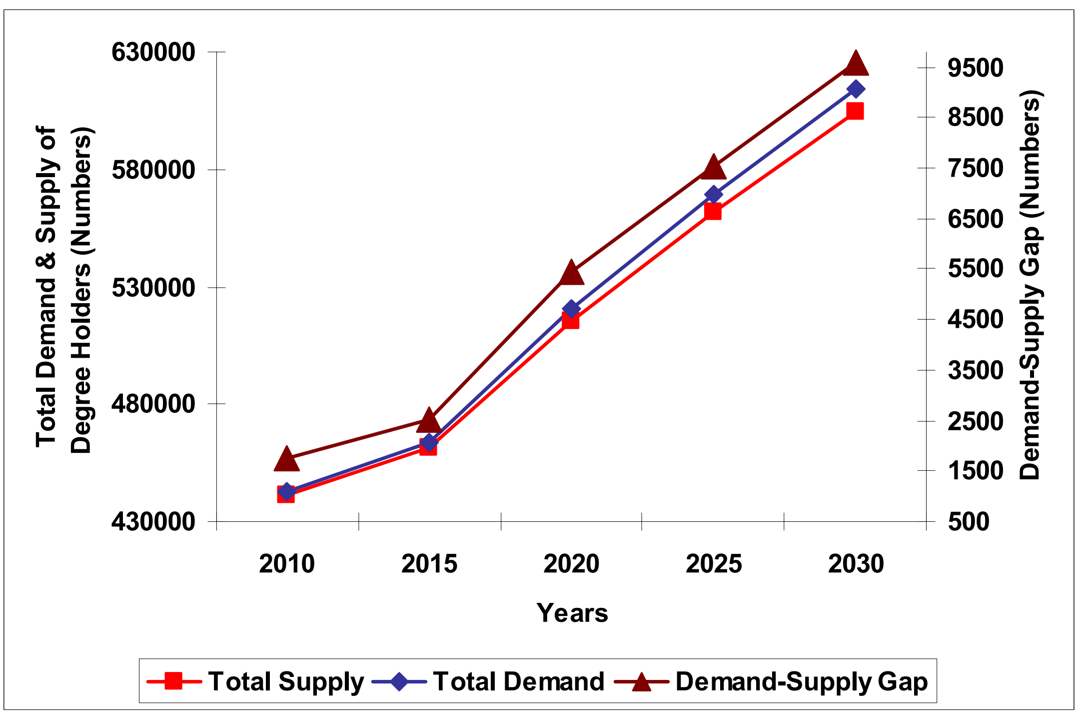

Figure 6. Overall agriculture demand-supply plot for degree holders for 50% increase in the intakes for 3% growth rate

Conclusion

This study has presented an integrated demand-supply model for manpower forecasting in agriculture sector in India. The results of the base run showed that the demand for agriculture sector manpower of degree holders in India would exceed the supply during the forecasting period (2010-2030) and hence a demand-supply gap exists. Thus, the technical manpower expected to be required in a greater number, will continue to be insufficient during the time horizon. The base run results in turn points towards the generation of more employment opportunities in the future for degree holders in agriculture sector in India.

After applying a policy of 50 percent increase in intake capacities at two different targeted sectoral growth rates of 4 percent and 3 percent, the demand-supply gaps were found to be reduced compared to the base run thereby alleviating the manpower shortages. However, the demand outpaces the supply and the manpower shortage continues unabated in future also. Hence, policy makers must think of appropriate intervention in the future such as extending the retirement period of the current stock employed etc. in order to balance the manpower supply and demand needs of the sector in future.

The current paper has some limitations. The Indian agriculture sector has sub-sectors in itself which are not discussed separately in this paper. Moreover, only technical manpower in agriculture sector in India is considered. Future studies can also be directed towards including the non-technical manpower requirements into the model.

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