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A Comparative Study of China's Township and Village Enterprises and India's Information Technology Industry

Tashi Phuntsok
Vidyasagar College, University of Calcutta, Kolkata, India
tashi09@gmail.com

Manoj Kumar
Centre for Economic Studies & Planning, School of Social Sciences (SSS-II),
Jawaharlal Nehru University, New Delhi, India
manojdiwakarstat@gmail.com

Abstract

The comparative study of China and India is focused on two sectors, which had an important role in the process of their respective socio-economic transition, namely the township and village enterprises in China, and information technology (IT) sector in India. Analysis includes the literature review that highlights the achievements on both sectors, development of both sectors and its relevance to the countries' economy as also present the institutional framework that has supported the development of China and India.

KEYWORDS: China, India, Township, Village, Enterprises, IT Industry

Introduction

China and India, the two Asian giants, started amid similar economic conditions during the reform period and but over a period, their development strategies and paths differed. China, on its part, experienced a very successful agricultural revolution that was successfully and efficiently transmitted to rural industrialisation and eventually to the urban industry. Overall, China's manufacturing industry followed the success of the agricultural sector. On the other hand, Indian economic reforms in agriculture did not achieve enough success to have an impact on the manufacturing industry. It was the digital revolution that placed the Indian economy on the path of success and continues to do so.

In this process of transition, two sectors in particular, have stood out to play an important role in China and India. These sectors, which are the focus of this paper, are township and village enterprise (TVEs) for China and information technology (IT) industry for India. IT would include specifically software development — and IT-enabled services (ITES, e.g., business process outsourcing, customer service, medical transcription, and financial research). The broad objective of this paper is to understand how these two sectors played an important part in the economic development and growth during the post reform period for both the economies.

The analysis is structured in five parts. The first part highlights the literature on the contribution of both these sectors. Following this is the objective and the methodology. The second section provides justifications to the logic behind the comparison of China and India and their relevance in comparison. Third and fourth section look at the overall development of TVEs and IT industry and shows their respective contribution to each country's economy, respectively. The final portion is a comparison between China and India'.

Literature Review

The performance of the TVEs' in the manufacturing industry has been widely regarded as the reason for the success of the Chinese economy and its acceptance is evident from many research papers in which TVEs have been quoted (Chang, 2008; Dani, 2008; North, 2008). Cheng (1996) states that "China's township and village enterprises (TVEs) are widely regarded as one of the major successes of the economic reform". Weitzman & Xu (1997) says "the driving force in the Chinese model is the so called TVE".

With the improvement in the performance of TVEs, the nature of TVEs have also changed – they got bigger in size and expanded in the urban areas. Due to these phenomenal changes in their nature, accompanied with spectacular performance, their performance in the external sector has also improved.

According to Wu & Cheng (1999), in 1993 TVE's export was US$ 25 billion which was 41 per cent of China's total export. Fheir analysis, TVEs export has witnessed a steady increase and plays an important role in this external sector. The paper by Peng (2001) not only acknowledged the performance of TVEs but it also shows how it outperformed State Owned Enterprises (SOEs) in terms of growth rate and productivity. It also provides three explanations to the reason for the TVEs performance. They are (i) informal or ambiguous private property rights of TVEs (ii) the advantage of small size and scale which allows easy monitoring of TVEs and (iii) it follows a strict market discipline.

The rate at which progress is taking place is very-well highlighted by Zhu (2008). According to him, in 1978, the rural share of China's industrial production was 7 percent, and by 1992, it had touched 50 percent, with an average annual increase of 26 percent throughout the 1980s. As for India, post-1990 the performance in the service sector has been marked with a new phase because of various factors (Eichengreen and Gupta, 2009). India's economic reform and the reform that followed played a huge role in integrating India into the global economy, accompanied by increasing trend in services across countries and India's advantage in its demographic dividend, skilled with knowledge of information technology and English (Chandrasekhar, 2001). It can be said that from 1990-91, the service sector led the economy, if we look in terms of percent of GDP which was 41 per cent (Rakshit, 2007).

The success of the service sector and more specifically the IT sector can be characterised as low investment and resources which are knowledge based and universally available (Chandrasekhar, 2001). According to the According to World Economic Forum (2003), India's IT industry is expected to grow at a compounded annual rate of 38 percent to reach $77 billion by 2008—contributing to 20 percent of India's anticipated GDP growth in this period and 30 percent of its foreign exchange earnings. Uniquely, the contribution of IT in the service sector is not only great but it also has a multiplier effect on the other sectors thereby having a greater role in the economic performance of India (Reserve Bank of India, 2008). The scope of expansion of IT sector has been there since 2000 with increasing flow of Foreign Direct Investment (FDI). The flows of FDI to India has been increasing by 24 percent between 2002 and 2003. The credit of this change also goes to the performance of the IT sector because of improving economic performance, continued liberalisation, and the growing competitiveness of Indian IT industries (IBRD, 1995).

Objectives

The above literature demonstrates the kind of role the two sectors have played. There are two objectives behind the comparative study. First, to understand the nature of contribution of these two sectors in their respective countries. Second, to understand how different or similar the nature of their success and failure.

Methodology

The comparative study lays down the grounds under which they can be compared (discussed in the following section). Second, we will then understand the kind of role the two sectors have played. For China, we investigate the performance of TVEs in terms of productivity, number of enterprises and gross output value. These parameters are compared with respect to other kinds of ownership. The study of TVEs is for the limited period till late-1990s because of structural transformation of ownership of TVEs that happened because of regressive privatisation that had followed. For India, we also look at the productivity of the IT sector, role of IT sector in distribution of service export, rate of growth of service sector and share towards GDP. The latter two parameters help us to indirectly understand the role of IT sector because of its dominant presence in the service sector.

In addition, for a comprehensive comparative study, these two sectors are perceived as an institution. Institutions here is defined according to North (1993:7) in a broad sense as a set of formal rules (constitutions, statute and common law, regulations), informal norms (norms, conventions and internally devised codes of conduct) and the enforcement of both. It is the various combination of rules, norms, and enforcement factor that determines economic performance of a nation.

To compare the role of the two institutions in their respective sector and economies, we investigate the following factors.

- Background to the informal institution formation
- Role of Government- formal institution support
- Contribution towards economy
    - Institutional role
    - Productivity
- Accommodating gradual change

China and India

China and India's comparison is not a new discourse; it has been happening since 1960s (Baark & Sigurdson, 1980). But more recently there has been a greater focus on China and India with regards to their performance. Some of the areas of focus for the study are GDP growth or FDI inflow, poverty, inequality, their role in global economy, etc. Hence, all these debates broadly question whether it was investment in infrastructure, economic reforms or institutional factors that contributed to the economic prosperity of China and India. This section provides the justification for the comparison of the two economies.

Firstly, the comparative study of the two economies would not only look at the initial conditions but also the process these two countries imbibed. Under many common factors, the comparative study of China and India could be a lesson for other developing countries. These two countries in the 1950's were very similar in their per capita GDP, share of labour force in agriculture, industry and other sectors and their share in agriculture, manufacturing, small-scale manufacturing and production in total output was the same (Saith, 2008). Besides, their size and population are quite similar both then as well as now. These factors justify the comparison between the two. Of course, these countries had their differences as well. Political, historical, and institutional backgrounds have played a major role in the process of development of their economies and thus their differences.

Secondly, another important factor justifying the comparative study is the period of comparison. A common period under study is considered important for any comparative study. In this regard, though China's economic reform began from 1978, the TVEs flourished during in 1980s and the IT industry in India opened for private entrepreneurs with internal deregulation during the mid 1980s (Evans, 1992; Yang, 2010).

Finally, China and India have had a very different growth and development trajectory since the reform, and the TVEs and the IT industry had a major role to play. But today, after half a century or more, these two countries couldn't be more different. In the year 2003, China's per capita income stood at twice that of India's; poverty level in both countries has come down but it's much better in China's case; China's life expectancy stands at 71, six years more than that of an average Indian; its adult literacy rate is 91 per cent compared to 65 per cent in India (Saith, 2008); India also lags behind China substantially on all key determinants of Total Factor Productivity (TFP) growth as suggested by the cross country evidence (Kuijs, 2012). Therefore, the comparative analysis of China and India's experiences may provide a great deal of useful insights into understanding the process of development.

China- Township and Village Enterprises (TVEs)

TVEs as an institution in China are a unique phenomenon in the sense that the emergence of rural entrepreneurs in this form has not been experienced in any other country on such a large scale and at such a rapid pace. TVEs are a product of evolution over a period and analyses of their emergence need to take into consideration the social, political, and economic influences on the formation TVEs. This is because the development of TVEs is not the outcome of any carefully designed policy or plan by the government. Nor is it a product of experiments conducted by the government.

The question as to what exactly is TVEs or a clear definition of a TVEs is a matter of great conflict because the concept of TVE contains an ownership dimension, a management dimension, and a locational dimension. Most TVE's industrial output is produced by firms that are controlled by local township and village governments. Despite the "collective" label, TVEs themselves were never wholly worker cooperatives. This is because the laws governing TVEs do not exclude privately-owned enterprises from that definition which function under a 'red cap'. This would mean that these enterprises are pretending to be a collective enterprise when they are private owned enterprise. According to Wu and Cheng (1999), as per the circular issued by the State Council of China (1984), the "TVEs include four types of enterprises: enterprises owned by townships, enterprises owned by villages, cooperatives formed by groups of rural residents and private family businesses". TVEs, which constituted one of the most dynamic sectors in the Chinese economy, has had a major contribution to the above development. Broadly, the contribution of TVEs performance can be investigated in three important aspects: its productivity, its number or strength and its gross output.

Productivity of TVEs

It has been argued that enterprise with clearly defined property rights are the preconditions for economic prosperity and 'proper functioning of a capitalist market economy' (Weitzman & Xu, 1997). In other words, an absence of well-defined private ownership is seen to adversely affect performance, leading to low productivity. According to this perspective, Private-Owned-Enterprises (POEs), i.e., the firms that are owned and controlled by domestic or foreign entities or individuals as sole proprietorships, private partnerships or private shareholding corporations, would outperform enterprises characterised by any other form of ownership such as Collective-Owned Enterprises (COEs) or SOEs.

Since TVEs are characterised by a form of collective ownership, in which the structure of the enterprise is such that the ownership and right to residual earnings are not clearly outlined, their performance, too, is expected to result in low productivity. But according to several surveys conducted by different scholars (Table 1), the collective sector, especially the TVE sector, has had a consistently a higher level of productivity not only than that of the SOEs, but also of the POEs. As a result of its high productivity, enterprises in the collective sector, especially the TVEs, have contributed greatly to the economy and economic growth in China since 1978.

Table 1: Relative efficiency of various ownership statuses

Empirical Evidence	POE	COE/TVE	SOE
Zhang et al., 2001 ● Technical Efficiency	66.78	68.77	55.34
Jefferson et al., 2000 ● TFP	3.2	3.1	1.9
Dong and Putterman, 1997 ● TFP		13.3 – 20.9% higher than that of POE	
Jefferson et al., 2000			
● TFP Growth in 1988-1992	2.11	3.13	2.11
● TFP Growth in 1992-1996	3.14	4.29	-1.11
Zhang and Parker, 2002 ● TFP Growth in 1990s	11.0	20.8	9.8

Source: Li, 2005.

Note: Technical efficiency is a measure of efficiency in terms of the difference between the real output and the potential output based on a stochastic production frontier model.

Number of TVEs

The increase in the number of TVEs is one of the indicators of the growth of the TVE sector, but this could not be sufficient as the size of the TVE sector would matter more in terms of output and employment generation. Nevertheless, we will investigate the TVE sector's growth in terms of enterprises, to get some idea as to how TVEs have grown or spread over a period. The Yearbook of National Bureau of Statistics of China provides us with a chapter on agriculture, which has data on number of TVEs from the year 1978 to 2002 and with distribution by number of enterprises under different ownership (see Table 2).

Table 2: Number of TVEs under Different Ownership (Unit: 10,000)

Year	Number of Township Enterprise	Collective Owned Units	Private Enterprises	Self Employed Individuals
1978	152.43	152.43		
1980	142.47	142.47		
1985	1222.50	156.90	53.30	1012.30
1989	1868.63	153.51	106.94	1608.18
1990	1873.44	145.39	97.88	1630.17
1991	1908.74	144.23	84.90	1679.61
1992	2091.96	152.72	90.18	1849.06
1993	2452.93	168.52	103.85	2180.55
1994	2494.47	164.10	78.64	2251.73
1995	2202.67	162.02	96.02	1944.63
1996	2336.33	154.89	226.42	1955.02
1997	2014.86	129.19	233.24	1652.43
1998	2003.94	106.58	222.20	1675.15
1999	2070.89	94.98	207.58	1769.23
2000	2084.66	80.21	206.06	1798.39
2001	2115.54	66.88	200.71	1847.95
2002	2132.69	73.15	229.79	1829.74

Source: China Statistical Yearbook, National Bureau of Statistics of China

Looking into TVE's growth in terms of number of enterprises for the period after reform till 2002, (Table 2) we get to see a unique movement in the number of TVEs. The data provided in Table 2 includes only enterprises at township and village level for 1978-1980, and it's only after 1985 that all types of TVEs are included (including collective owned units, private enterprises and self-employed individuals). The data shows a huge jump in the number of enterprises from 1.52 million in the year 1978 to 12.23 million in the year 1985, which amounts to an increase of 702 per cent. Of course, we cannot attribute such a huge increase in the number of enterprises to the exclusion of certain TVEs. Such a great change in the number of TVEs must be attributed to the 'household contract responsibility system' (HCRS), initiated in the 1970s. Under this system, TVEs started operating under the contract responsibility system which encouraged setting up of small production brigades.

As compared to the 1978-85 period, the number of TVEs grew steadily for the period from 1985 to 1994, and thereafter the numbers tend to fall gradually. Surprisingly, to a large extent, the growth of the TVEs was neither planned nor anticipated. Such businesses neither received funding nor technological aid from the central government like the SOEs did in the beginning. However, they were also free of the extensive regulation by the central government typically associated with state businesses. This gave the TVEs the independence to decide as to what to produce and enjoy greater benefit from the outcome which acted as an incentive to work. Such performance greatly relieved the government, which was burdened by the failure of many SOEs, which were seen as the form of enterprise that would guarantee self-sufficiency.

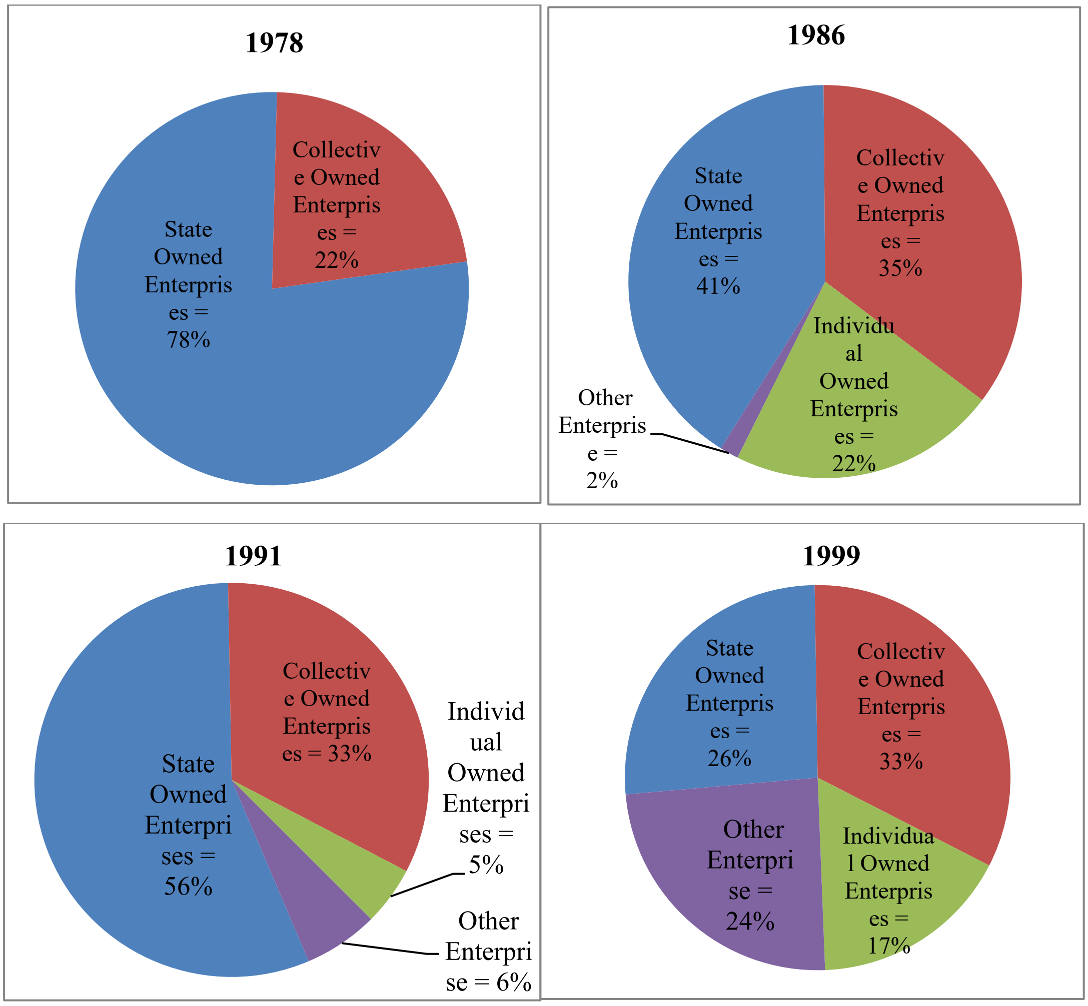
Gross Output Value

This section deals with the role of TVEs in the manufacturing industry in terms of output and its comparative performance relative to other enterprises. But the data for gross output values, specifically for TVEs, are only available for some initial years. Hence, for this section we treat the performance of 'collective owned enterprises' as a group being indicative for the performance of TVEs. There are two reasons why this may be justified. First, TVEs are by nature collectively owned enterprises. Second, a stronger reason would be that, for the limited period for which the data for TVEs is available in terms of value of gross output, the share of TVEs in the total number of collective enterprises is higher than 50 per cent and this is also true in terms of the number of enterprises.

Figure 1 shows the share of each type of enterprise and how these have changed over the years 1978, 1991 and 1999. The figures for the year 1978 and 1999 show that there has not been any drastic change in the share structure. The SOEs had been the dominant shareholder with 78 per cent and COEs with 22 per cent in the beginning of the reform. The figures for the year 1986 and 1991 show some change in the composition. The SOEs share has come down to around 50 per cent whereas COEs share has gone up to around 30 per cent from 22 per cent. However, things take a completely different turn when we look at the pie chart figure for year

1999, with the share of traditional enterprises such as SOE and COEs share coming down to 26 per cent and 33 per cent, respectively, for that year. On the other hand, the 'individually owned enterprises' and 'enterprises of other types of ownership' which together constituted 11 per cent share in 1991 have seen an increase to 17 per cent and 24 per cent, respectively, in the year 1999.

Figure 1: Gross Output Value under Different Ownership



Source: Secondary data of Gross output value of China & linked to Table A.1 (Appendix)

This increasing share of 'individually owned enterprises' and 'enterprises of other types of ownership' only explains the diminishing share of the SOEs. By the latter half of 1990, the share of COEs, more specifically the TVEs, began to dwindle because of the massive drive of different forms of privatisation (Yusuf, Nabeshima, and Perkins 2006). Privatisation in the nature of corporatisation, Manager buy-out (MBO), joint-stock cooperation, etc., followed which ultimately saw the disappearance of TVEs (Lu, 2007; Naughton, 2006).

India: IT Industry

The initial seed to IT revolution was sowed in the late 1960s when the Indian government discovered the strategic importance of IT and its future scope and environment then were closed, and protectionist policy followed by the government (Brunner 1991; Taganas and Kaul 2006). To meet the rising demand in the sector, the government handed the responsibility to a public sector enterprise, Electronics Corporation of India Limited (ECIL) in 1971, to produce indigenous computer. What followed created a difficult situation for India. When it first set up, ECIL promised to meet the domestic demand by 1976 but struggled to fulfil the promise (Brunner, 1991). Second, the only private companies that were in the IT business then were Tata Consulting Services (TCS) and Tata Burroughs Limited (TBL), both part of I.T.C. Limited (now ITC). Third, the multinational companies, IBM (International Business Machine) and ICL (International Computers Ltd.) which supplied the basic software and hardware need, met with controversy for supplying under graded technology (Subramanian, 2006). Because of this, it was decided to "expel" IBM and ICL from India in the year 1976. This added another problem to the existing under performance of ECIL. Also, the layoff of more than 1,200 IT professionals in IBM and more in ICL was something that the government was not prepared for (Kumar & Seith, 2005). It was under such circumstances that the New Computer Policy (NCP) and New Electronics Policy (NEP) were announced in 1984 and finally decided to opt for a policy shift from 1986 onwards (Taganas & Kaul, 2006). This change in policy allowed the existing private enterprise and new enterprise to finally enter the IT market with many relaxations in the domestic functioning and on the external front in terms of import of capital goods. It can be said that the coming of Tata Consulting Services (TCS) in 1968, Patni Computer Systems (PCS) in 1978 and other private IT entrepreneurs that followed set off the IT revolution.

But the path to the course was not smooth because of infrastructure problems and the high level of bureaucratic interference added to the complication. For instance, the basic requirement of finance (e.g., loan and raising capital from the market) and raw material (e.g., iron and coal) required dependence on government enterprise. This would mean building relationship with bureaucrats or a periodical visit to government departments, mostly in Delhi (Cheng, 1996; Murthy, 2000; Nilekani, 2008). Even starting a new business or expansion of business required undergoing the same problems because of the government's dominance in finance and raw material sectors, and stringent rules.

It was under such an environment during the 1980s, where every aspect of business of the IT sector was controlled by the government and continuing difficulties in obtaining hardware and software, along with the rising costs, that led to difficult circumstances. It was under such desperate circumstances that some entrepreneurial companies and computer professionals set up their own business to meet domestic demand and tap the future potential of the software industry (Kumar & Seith, 2005). It was during this period that Tata Consultancy Services (TCS) and TBL were joined by several other companies like Hinditron, Patni Computer System, Datamatics, Infosys and Wipro to exploit the opportunities in domestic and foreign markets. From the early 1970s till the time of the computer policy liberalisation, the India software export market was dominated by TCS and TBL, who accounted for 67 percent of India's software exports (Subramanian 2006, p. 39).

The only saving grace during that time was the very nature of the service sector (specifically IT sector) characterised by less dependence on capital, labour and infrastructure compared to other sectors and “universally available knowledge-base for innovation” which made establishment of IT business much easy (Chandrasekhar, 2001). So, the circumstances under which private players ventured and dominated the IT service was not only a matter of coincidence or accident but a product of frustration, desperation and desire for an alternative (Bhatnagar, 2006). A little relief also came in the form of reform, starting with internal deregulation in the 1980s and liberalisation of trade in services from 1991s (Panagariya, 2004). Government initiatives (discussed later) and the leadership of young Prime Minister Rajiv Gandhi also mattered in the path of development of the IT industry.

IT Industry’s Contribution to Indian Economy

The success of the Indian software industry has had wide-ranging effects across the Indian economy, both qualitatively and quantitatively. In the process, the Indian diaspora has played a crucial role in building bridges between the Indian software companies in India and the IT industry abroad and in setting the standard of Indian IT industry (Bhatnagar 2006; Kapur, 2002). India’s image in the world changed quite substantially with the success of the Indian diaspora in the Silicon Valley. All this has created a brand name, wherein “India or Indian” is directly associated with software programmer quality just like “Japan or Japanese” are labelled for consumer electronics. This brand image of India’s IT talent has not just touched the US but has also spread to countries across the world wherever Indians have gone (UK, Germany, Finland, Japan and South Korea).

Productivity of Service

The productivity indicator in terms of Total Factor Productivity (TFP) explains how the IT sector has been growing since 1980 from Table 3. The TFP measure is conducted under the KLEMS project which estimates productivity in the Capital, Labour, Energy, Material and

Services (KLEMS) which is also applied in many countries across the world to enable database which helps to compare across countries and sectors.[1]

Table 3: Total Factor Productivity (TFP) and GDP Growth

Sector	1980-1986		1986-1991		1992-1997		1997-1995		1980-2005	
	TFP	GDP	TFP	GDP	TFP	GDP	TFP	GDP	TFP	GDP
Total Economy	2.2	5.3	1.6	5.9	2.6	6.5	1.7	5.7	1.9	5.7
Agriculture	2.5	3.7	2.4	3.8	3.0	4.8	-0.2	2.2	1.6	3.4
Industry	-0.3	6.2	1.6	7.2	3.1	7.3	1.4	5.1	1.4	6.0
Services	3.4	5.8	1.0	6.9	2.0	7.3	2.2	7.9	2.1	7.0

Source: Reserve Bank of India Annual Report

Except for two periods 1986-1991 and 1992-1997, the productivity of the service sector has been very impressive by being above the national average both in terms of TFP and GDP. The overall GDP for the period 1980-2005 also shows 2.1 and 7.0 for TFP and GDP, respectively, both above the national average. Further a study by (Goldar et al., 2017) for the period of 35 years from 1980 to 2014 also indicates the dominant performance of service sector productivity in the overall productivity growth of the economy for the period. The productivity performance explains the share of the service sector in GDP, the rate of growth of the IT sector and share of the IT sector in export (discussed below).

Contribution in terms of Exports

Since the economic liberalisation post-1991, the service sector has been the driving force behind the high economic growth. This demand for the service sector is predominantly from the external sector (Chandrasekhar et al., 2006). Due to the tremendous increase in the number of IT companies in and outside India, there has been an increasing demand for Indian IT services and software export. A big share of the export in the service sector is from the IT sector, especially from the US and Europe. Export from the IT sector is growing at an average rate of 40% from 1995-96 and this to explains the performance of the service sector (Table 4**)**. In 2005-06, the share of exports of software and services was at $17.7 billion, which is a fifth of India's merchandise exports and this is higher than export of textile and textile products (including carpets), the principal commodity of exports (Chandrasekhar et al., 2006).

[1] The framework of productivity estimates is given in Reserve Bank of India Annual Report 20009-10.

Table 4: Indian Services and Software Exports (US $ million)

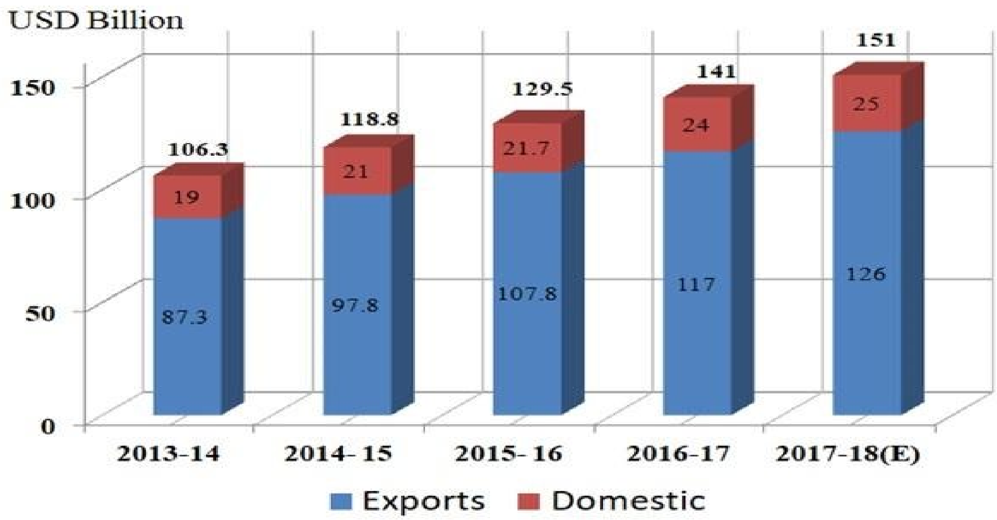
Year	IT Services Exports	ITES-BPO Exports	Total Software and Services Exports	Growth over previous year (percent)
1995-1996	754	---------------	754	NA
1996-1997	1,100	---------------	1,100	46%
1997-1998	1,759	---------------	1,759	60%
1998-1999	2,600	---------------	2,600	48%
1999-2000	3,397	565	3,962	52%
2000-2001	5,287	930	6,217	57%
2001-2002	6,152	1,495	7,647	23%
2002-2003	7,045	2,500	9,545	25%
2003-2004	9,200	3,600	12,800	34%
2004-2005	13,100	4,600	17,700	38%
2005-2006	17,300	6,300	23,600	33%
2006-2007	22,900	8,400	31,300	33%

Source: Compilation from various Reserve Bank of India Annual Report

Note: ITES: IT Enabled Services; BPO: Business Process Outsource

Figure 2 shows the consistency of performance of the IT sector in terms of revenue generated. For the year 20017-18E the revenue generated from the export is US$ 126 billion which is more than 80% of total revenue generated

Figure 2: Distribution of IT sector revenue generations



Source: Government of India, Ministry of Electronics & Information Technology (E = Estimated)

Distribution of Service Export

Service sector productivity has been dominant in the overall productivity growth of the economy for the period 1980 to 2014 (Goldar et al., 2017). Table 5 shows the distribution of service exports. The software export constitutes the largest share (around 40%) of the total services export for the period the data is available. Not only is the IT industry growing at a great pace, but it has constituted the highest and major share of service export. The IT Service share of exports in the IT-ITeS sector has been increasing since 2013-14. The share of IT service is more than 55% for all the years from 2013-14 to 2017-2018 (Table 6). The Compound Annual Growth Rate (CAGR) for this period is more than 10 per cent. The ITeS-BPO holds the second largest share after IT service with a CAGR of more than 9 per cent.

Table 5: Structure of Indian IT sector Exports I (US $ million)

Year	Amount	Share in Total Services Exports (per cent)					
	(US $ m)	Travel	Transp-ortation	Insuran-ce	G.N.I.E	Software	Miscellaneous
1970-71	292	16.8	49.7	5.5	13.7	-------	14.4
1980-81	2,804	43.5	16.3	2.3	4.0	-------	33.9
1990-91	4,551	32.0	21.6	2.4	0.3	-----	43.6
2000-01	16,268	21.5	12.6	1.7	4.0	39.0	21.3
2003-04	26,868	18.7	11.9	1.6	0.9	47.6	19.2
2004-05	46,031	14.1	10.4	2.0	0.7	37.4	35.4
2005-06	60,610	12.9	10.4	1.7	0.5	38.9	35.6

Source: Compilation from various Reserve Bank of India, Annual Report

Table 6: Structure of Indian IT sector Exports II (US$ billion)

Year/ Segment	2013- 14	2014-15	2015-16	2016 -17	2017-18 (E)	CAGR % (2013-18)
IT Service	49.2	55.3	61.0	66.0	69.3	10.07
ITeS-BPO	20.4	22.5	24.4	26.0	28.4	9.19
Software Products, Engineering Services, R&D	17.7	20.0	22.4	25.0	28.3	13.09
Total IT-ITeS	87.3	97.8	107.8	117.0	126.0	10.32

Source: Government of India, Ministry of Electronics & Information Technology

Rate of Growth of service sector and share to GDP

Finally, the increasing rate of growth of the service sector and its increasing participation in the growth rate of GDP since the 1990s reveal significantly that the Indian IT industry contributes immensely to the growth of the service sector and eventually to the growth of GDP (Table 7). Service sector contribution to GDP for the 1990s decade stands a little more than 40 per cent. For the decade starting 2000, it is steadily increasing from 50 per cent to nearly touching 60 per cent share in GDP. And for most of the year after 1990-91, the rate of growth of the service sector is much higher than the GDP growth rate, also indicating that despite non-performance from the other sectors (agriculture and manufacturing), the good service growth record maintained a good GDP growth rate.

The challenges and way forward

Given the list of advantages that India enjoys which greatly contributes to the success of the IT industry, there still lies challenges. The challenges are from intense competition, innovation, and patent rights (Dhar & Joseph, 2019). Most important of the challenge of patenting computer programmes. Since the inception of Patents Act, 1970, India's patent law has not been able to change the existing system which would give a great boost to the innovations. But lately, the Controller General of Patents, Designs and Trademarks and new Court ruling are helping to clarify the nature of computer programme (Dhar and Joseph, 2019).

Comparison between China's TVEs and India IT sector

As of today, China and India are known to have performed exceptionally well in the manufacturing and service sector, respectively. Not only have these two sectors boosted domestic economy, but it has also played a dominant role in the world. China is known as the "factory of the world" or "manufacturer for the world" (Xiangguo, 2007) and India or Indian is associated as being the "software programmer" in the world. This final section helps understand how different roles have been played by these two institutions in the economic progress of these two countries both domestically and internationally.

Background to the Informal Institution Formation

One similarity between China's TVEs and India's IT industry, is the circumstances under which these institutions were formed. In both the cases, not only was the economic scenario unfavourable for the private player to thrive, but it was also discouraging and following a communist and socialist policies respectively. It was only in 1978 when Party Secretary Zhao Ziyang and Wan Li in Sichuan and Anhui allowed local initiatives to farm uncultivated land, fix specialised contracts and task rates and contract production to work groups. All this shifted the production decision from the State to the household and this became the key source for the most important transformation in rural China. The formation of institutions mentioned was the outcome of desperate measures by individuals and groups, without much support from the government. It was only later when the light of success began to shine that the government became more liberal and helpful in both the countries.

Table 7: GDP growth rate, service sector growth rate and service sector share to GDP at constant 2004-05 prices.

Financial Year	GDP growth rate	Service growth rate	Share to Total GDP at Current Prices (%)
1989- 1990	6.13	8.88	42.58
1990-1991	5.29	5.19	42.55
1991-1992	1.43	4.69	43.91
1992-1993	5.36	5.69	44.05
1993-1994	5.68	7.38	44.05
1994-1995	6.39	5.84	44.52
1995-1996	7.29	10.11	45.69
1996-1997	7.97	7.53	45.51
1997-1998	4.30	8.93	47.53
1998-1999	6.68	8.28	48.24
1999-2000	8.00	12.05	50.05
2000-2001	4.15	5.07	50.49
2001-2002	5.39	6.61	51.07
2002-2003	3.88	6.74	52.48
2003-2004	7.97	7.89	52.44
2004-2005	7.05	8.28	53.05
2005-2006	9.48	10.91	53.74
2006-2007	9.57	10.06	53.98
2007-2008	9.32	10.27	54.45
2008-2009	6.72	9.98	56.11
2009-2010	8.59	10.50	57.09
2010-2011	9.32	9.75	57.32
2011-2012	6.21	8.20	58.39
2012-2013	4.99	7.11	59.57

Source: Data Book, Planning Commission of India (2014)

Note: GDP and Service sector growth rate are at factor cost at constant price (2004-05 prices)

China and India have had a very similar kind of development in terms of manufacturing and IT industry boom, respectively. The institutional base to these sectors is the product of desperate measures (discussed before) by the people and it is only later when the impact of these institutions began to translate into economic development that we see some form of acceptance in terms of change in ruling government's ideology or the formalisation of institutions, starting with support from the state.

Role of Government - Formal Institution Support

Just as China is known for its manufacturing power in the world, India's IT industry made it famous across the world as a service provider. As we have learned before, the institutional arrangement in India during the 1980s was such that private technological capabilities were stronger and it was the private entrepreneurs who were the initiators of technological change, while the government facilitated the process through deregulation or liberalisation which triggered the adoption of new technologies in nascent IT sectors. The government's role in China was also similar in nature, with reform measures only playing the role of facilitator (as discussed before).

Different government organisations, in some way or the other, played a supporting role for both the countries. Just as the Chinese government concentrated on its infrastructure investment for manufacturing exports in SEZs (special economic zones), very similar EPZ and STPs, under the Department of Electronics, were set up to provide much needed infrastructure: broadband communication networks, reliable infrastructure, tax relief, etc. (Kumar & Seith, 2005). In 1988, the Indian Commerce Ministry sponsored the formation of Electronics and Software Export Promotion Council and the NASSCOM (a software industry trade association) to promote the service and export of the IT industry. The setting up of IT training institutions and encouragement in creation of private engineering colleges were some of the initiatives taken by the Ministry of Human Resources Development, India. These institutions for learning, research, and development (in the field of hardware and software related services) ensured adequate supply and quality of the technical labour force. The Reserve Bank of India also adopted several measures to support the IT industry. It simplified the filing of Software Export Declaration Form (SOFTEX) and the process of acquisition of overseas parent company shares by employees of the Indian company and foreign exchange could be freely remitted for buying services (Bhatnagar 2006).

Contribution towards Economy

Institution Role

The overall experimental nature of institution formation in China had a great impact on its economic performance. The experiment with HFs, contract responsibility system (CRS), shareholding system and most important of all the TVEs, greatly influenced the course of the Chinese economy. Particularly the contribution in terms of number of TVEs, gross output, productivity, and its implication on other types of enterprise through competition and development of rural poor has been well documented. TVEs had a very steady growth and its contribution to the manufacturing sector was immense until 1994, after which it started to steadily diminish with privatisation of different forms.

Like China's TVEs, the Indian IT industry also had a major impact on its economy. India's IT industry also grew immensely in number by attracting a great amount of foreign direct investment (FDI). The overall share of the service sector in GDP and its contribution in terms of software exports had a tremendous growth, and it had a great proportion of share in the total export of services. And most importantly, with the IT industry playing a great role in the Indian service sector, the share of the service sector in the GDP has immensely grown after the reform period and it continues to do so.

Productivity

The performance of any economic sector is greatly dependent on the efficiency with which the resources have been used. And there are various methods used and one such method is TFP which is commonly used to check the performance. The performance of TFP of respective sectors of the two economies have been analysed. And it has been found in both these cases that the reason for their exceptional performance has greatly to do with the productivity in terms of TFP. From the various studies done on the performance of TVEs vis-a-vis other kinds of ownership, their performance stands out. Similarly for the IT sector too, in the Indian case core of the service driven economy can greatly be attributed to the performance of IT especially in terms of TFP and when compared with other sectors. This also explains the reasons for the high rate of growth of the IT sector and having a dominant share in the GDP.

Accommodating Gradual Change

Another similarity in China and India was in terms of speed at which TVEs and IT evolved from the start. It has been very gradual in nature, taking each step very cautiously. The theoretical rooting and the success in the gradual policy applied have some differences if looked carefully. In China, the foundation of gradualism lies in the dual-track system (DTS). Under this system, the new and old systems coexisted during and after the reform until the old system was completely overtaken by the new (Gang, 1994; Ma, 2008). Dual pricing, exchange rate, ownership, and output, are some of the examples experienced in China. In the shock therapy, the old systems are destroyed or abandoned with the establishment of the new system.

Ownership has been one of the most important forms of DTS (Gang, 1994). TVEs is one of the initial experiments with the ownership which became very successful. Furthermore, the practice of other forms of ownership such as private, shareholding enterprises, foreign joint-ventures, and individual business are examples of practice of gradualism through DTS in ownership.

Gradualism in India's case is logically based on the political ideological inclination and macroeconomic conditioning. It has been a cautious measure taken with the intention of hurting the least and moving further. That is also the reason why sectors such as industry, labour, agriculture, insurance, etc., were less reformed or reformed slowly because of 'mass politics' involved in it (Sach et al., 1999). For a variety of reasons, the gradualism in IT performance has been natural and not planned. First, the economic philosophy that guided the government during the 1980s and macroeconomic problems that were slowly accumulating which eventually led to the economic crisis in 1991 and the series of reforms that followed played an important role in laying down a much more conducive environment than one in the pre-1980 period. Second, the international factor also played an important role in assisting the IT sector through the flow of FDI in this sector.

Finally, as mentioned before, the "universally available knowledge-base for innovation" which made the transfer of knowledge from West to India easy because of NRI who were already there. More recently, because of the presence of various educational and research institutions, IT companies and technical and English-speaking youths, the growth of the IT industry has been endogenously generated.

Conclusion

This comprehensive study of two institutions in China and India since the reform period presents a wide array of institutions that have played an influential role in the overall development of these countries. Though the process and the result might be different for both, the impact of institutional role cannot be denied. For instance, institutional participation or association was completely different in these two countries. China's TVEs reached more to the masses, particularly in the rural areas, cutting down inequalities, whereas in India, the IT boom only touched certain sections of the urban rich, thereby amplifying India's inequalities (Chandrasekhar, 2001).

The major difference also lies in the long- term achievement. TVEs, an institution with 'Chinese characteristics', were more in the nature of a temporary substitute, which played a great role during a particular period but slowly perished over time. But in India's case, the IT industry was perennial in nature, whose success only grew with lasting impact on the Indian economy. So, one significant difference between China's TVEs and India's IT industry is longevity. India's IT boom, unlike China's TVEs, was more permanent in nature, whose impact on the Indian economy is still prevailing and flourishing further.

The experiences of these two nations, representing different blocks of Asia, are an exemplary demonstration of heterogeneity of economic development for many developing countries. This is especially true because their mammoth size, heterogeneity and their social, political, and economic backgrounds could be a great example for many smaller countries that are in the process of development.

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Appendix

Table A1: Gross Output Value of Industry (Unit: 100 million Yuan)

Year	Total	State Owned	Collective Owned	Individual Owned	Other Enterprise
1978	4237	3289	948	----	---
1980	5154	3916	1213	1	24
1985	9716	6302	3117	180	117
1st Period: 1978-1985 increase	**129.31%**	**91.61%**	**228.80%**	**180%**	**117%**
1986	11194	6971	3752	309	163
1987	13813	8250	4782	502	279
1988	18224	10351	6587	791	495
1989	22017	12343	7858	1058	758
1990	23924	13064	8523	1290	1047
2nd Period: 1986-1990 increase	**113.72%**	**87.41%**	**127.16%**	**317.48%**	**542.33%**
1991	26625	14955	8783	1287	1600
1992	34599	17824	12135	2006	2634
1993	48402	22725	16464	3861	5352
1994	70176	26201	26472	7082	10421
1995	91894	31220	33623	11821	15231
3rd Period: 1991 1995 increase	**245.14%**	**108.76%**	**282.82%**	**818.50%**	**851.94%**
1996	99595	36173	39232	15420	16582
1997	113733	35968	43347	20376	20982
1998	119048	33621	45730	20372	27270
1999	126111	35571	44607	22928	32962
4th Period: 1996-1999 increase	**26.62%**	**-1.66%**	**13.70%**	**48.69%**	**98.78%**

Source: China Statistical Yearbook, National Bureau of Statistics of China

a) Figures in this table are at current prices

b) Figures for 1949-1957 of other ownership refer to state and private joint ownership enterprises and private ownership enterprises.

c) Figures for state-owned industrial output value exclude 460 billion Yuan earned by state-owned holding company.

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Profitability prediction in Public Enterprise contracts

Naresh C Saxena

Independent researcher, Canada

drncsaxena@gmail.com

Abstract

Across the world, the governments are seeking to enhance the performance their public enterprises This process involves changing the mindset of public enterprise executives from that of a government bureaucrat to that of a business leader. This includes running public sector enterprises profitably. As agriculture transforms itself from a subsistence activity to agribusiness across the world, the importance of agribusiness construction is increasing. Commercial managers employed by public sector enterprises are asked to estimate the expected profit on a prospective contract to either decide whether to proceed with the project or to aid in financial forecasting for the company. The estimation of a prospective contract's profitability is generally done by intuition. A mathematical model to aid in predicting the profitability of a prospective contract would be of immense use to public sector enterprises and can be used as a tool to ward off political interference. Furthermore, it would of considerable interest to commercial managers to know the effect on predicted profitability of a contract should they change the value of an attribute of a prospective contract. The application will, however, require close interaction between IT professionals and public enterprise executives.

KEYWORDS: Construction, Agribusiness, Profitability, Machine Learning

Introduction

While the public sector enterprises in the field of manufacturing and services are being privatised the world over, agriculture still remains in the publics sector in developing countries. This includes irrigation and output like marketing facilities.

Construction plays an important role in the development of a strong agricultural economy. This is evidenced by the need to construct efficient farm-to-market roads, irrigation channels, bridges, grain silos, and facilities to produce and store agricultural goods. Agricultural construction spans a wide range of projects Primary projects are those that directly affect farmers and their ability to work. These projects include the building of barns and silos, seed and grain processing, hog production, and dairy production facilities. Secondary projects include essential infrastructure within a country. These construction projects involve the building of large warehouses, farm-to-market roads and similar projects.

Public sector working has been transformed in developing countries and profit has ceased to be a dirty word. One of the tasks of a public enterprise manager in agribusiness construction is to estimate the expected profit on a prospective contract in a competitive market. On the basis of this assessment, the company can decide whether to bid for the contract and the amount and nature of bid. Formal and analytical risk models prescribe how risk should be incorporated into construction bids. However, the actual process of how contractors and their clients negotiate and agree to price is complex and not clearly articulated in the literature (Laryea & Hughes, 2011). In any case, the company needs to estimate the profitability before any decision on the bid can be taken.

The estimation of a prospective contract's profitability is difficult due to the range of size and types of contracts and the types of work undertaken. Furthermore, some agribusiness construction companies specialise into a particular type of work whereas others take on many different types and sizes of work. Moreover, the profitability of a contract would certainly be influenced by the attitude of the client. While some may be extremely austere on payments made to the agribusiness construction company and often hold back payment (a process known as retention) until the very last stages of the contract, others may be less stringent due to internal factors.

Internal management of the contract heavily influences the profitability of a contract. The performance of the personnel assigned to the construction project has an influence on profitability. Other factors that influence the profitability of a contract include suppliers, productivity and availability of labour. Furthermore, most agribusiness construction companies employ subcontractors, which are other companies, on medium to large contracts usually for over half the work on the contract – and sometimes for the most of the work. The performance of the subcontractors can greatly affect the profitability of a contract if not supervised correctly.

Finally, apart from contract types and internal management, the profitability of a contract can be affected by unforeseen circumstances (Cooke & Williams, 2009). For example, a new government or local scheme can change the availability of labour and timely completion of a contract. If a contract requires specialist materials from a distant supplier, a sudden rise in global oil prices will increase costs for the contract, and if it is not possible to pass this extra cost onto the client, the profitability will be severely affected. In agribusiness construction, uncertainties are more as most of the works are 'off road'. Consequent to globalisation of agribusiness, agribusiness construction companies are spreading their business to developing countries. This internationalisation has increased risk for companies as developing countries pose greater uncertainties to these companies (Jaselskis & Talukhaba, 1998). Other risk factors are approvals and permits, changes in law and government policy, law enforcement, local partner's creditworthiness, political instability, higher inflation and changing interest rates and government influence on dispute resolution. The risks at country level are more severe than that at market level and the latter are more severe than that at project level (Wang et al., 2004).

Due to the number of variables and a large number of attribute values of the variables, it is not possible to use traditional *if-then-else* type of deterministic programming to make predictions about the profitability of a prospective contract. In such situations, application of Machine Learning is gaining wide acceptance as a useful tool in business research. While popular business applications of machine learning are in the field of finance and marketing, newer applications are public sector applications like healthcare. The objective of this paper is to create a Contract Profitability Prediction System using a Machine Learning algorithm that would predict the expected profitability of contracts at their starting point as well as to identify contract attributes which most influence profitability. Unfortunately, no prior Contract Profitability Prediction System exists which could have served as a template to improve upon. This paper describes the system developed and the data analysis undertaken and attempts to apply existing mathematical techniques and algorithms as a solution to a commercial problem.

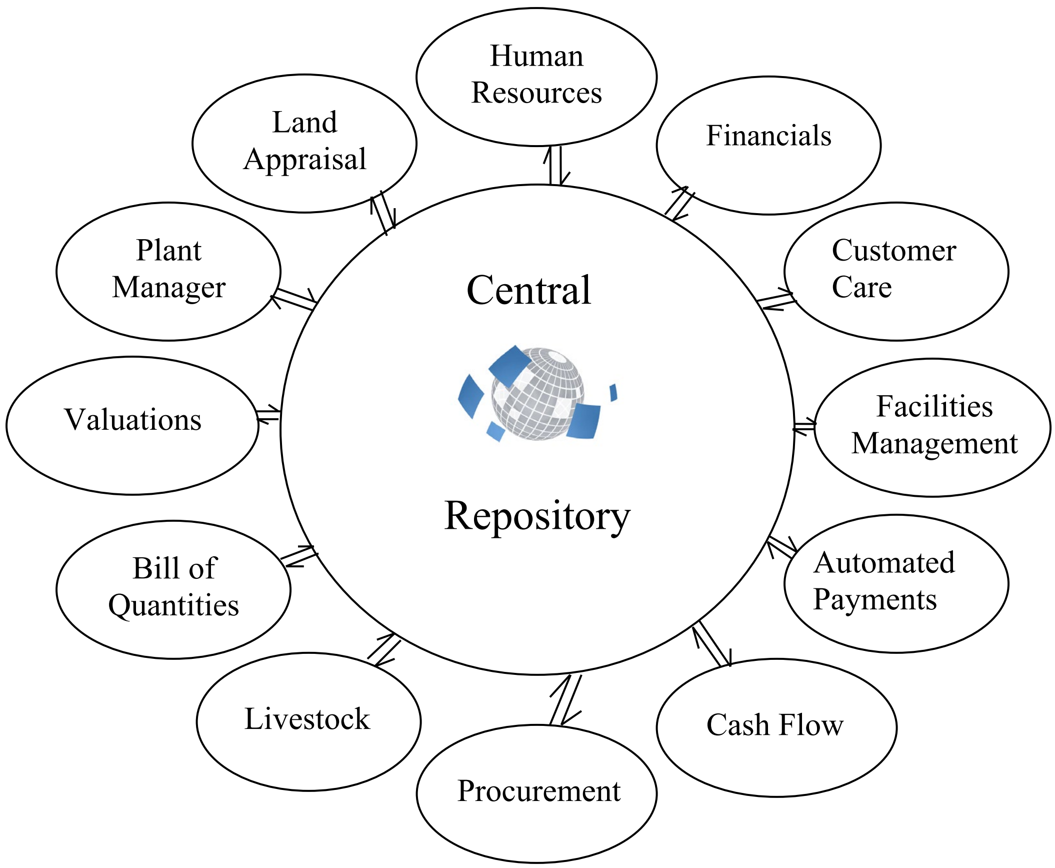
Managing contracts

In the construction business we find mainly two types of contracts. Fixed-price contracts provide strong cost-minimization incentives for the construction company, but raise the spectre of hold-up when the contract must be renegotiated to accommodate modifications to the project. In contrast, cost-plus contracts provide flexibility, since the principal continues to direct work on the project, but create essentially no incentive for cost-minimisation since the construction company is fully reimbursed for its costs (Corts, 2012). In agribusiness construction, fixed price contracts are more common.

Estimation of the value of construction works of a contract undertaken by an agribusiness construction company is done by a Quantity Surveyors (QS). The QS keeps control of the costs and revenues of the contract as well as dealing with unforeseen circumstances and delays which may affect the profitability of the contract (Harris & McCaffer, 2013). The QS generally submits a Cost Value Reconciliation (CVR) either monthly or quarterly which informs the management about the state of the contract. Commercial managers in agribusiness construction companies are usually senior or former QSs, who assist the management in bidding for prospective contracts, and assist in the management of ongoing contracts. The QS keeps control of the costs and revenues of the contract and deals with unforeseen circumstances and delays which may affect the profitability of the contract. The QS submits a Cost Value Reconciliation (CVR) either monthly or quarterly which informs the management about the state of the contract.

One of the most pervasive organisational change activities that occurred in the last decade of the twentieth century is the implementation of Enterprise Resource Planning (ERP) systems (Davenport, 2000; Jarvenpaa & Stoddard, 1998). An ERP system is a packaged business software system that enables a company to manage the efficient and effective use of resources (materials, human resources, finance, etc.) by providing an integrated solution for the organization’s information processing needs (Nah et al., 2001). The architecture of the software facilitates transparent integration of modules providing flow of information between all functions within the construction company in a consistently visible manner. Corporate computing with ERP system allows construction companies to implement a single integrated system by replacing or re-engineering their mostly incompatible legacy information systems (Chan, 2009). Figure 1 shows a typical ERP system in a typical agribusiness construction company.

Figure 1: ERP in a typical Agribusiness construction company



A typical ERP implementation in a large agribusiness construction firm takes between one and three years to complete and costs tens to hundreds of thousands of dollars. Several practitioners are of the view that ERP implementations yield more failures than successes in large construction firms (Voordijk, 2013). ERP casts a big shadow on the employees, changing the nature of tasks and workflows, and often the jobs themselves (Davenport et al., 1996). The agribusiness construction industry is characterized by activities that are discontinuous, dispersed, diverse and distinct in nature. Construction work is a demanding and stressful and construction teams often work day and night under incessant pressure to meet deadlines. The main concern of the project personnel is ‘to get the work done’ as early as possible to reduce project time. Under such circumstances it is extremely difficult for the people to provide a creative response to proposed changes. A major change is bound to cause problems (Johns, 2006). The success or failure of an ERP system implementation is rarely tied to the features of the technology itself; more often it is linked to the job and processes reengineering that typically accompany such systems (Peppard, & Ward, 2005).

Notwithstanding these problems, more and more agribusinesses construction companies are switching over to ERP, not as an end in itself but for realisation of organisational goals (Martin & Huq, 2007). Popular commercial ERP systems include SAP Business Suite, JD Edwards EnterpriseOne, Oracle E-Business Suite, and PeopleSoft (by Oracle), Microsoft Dynamics and an open-source free-to-use ERP system GNU Enterprise (GNUe).

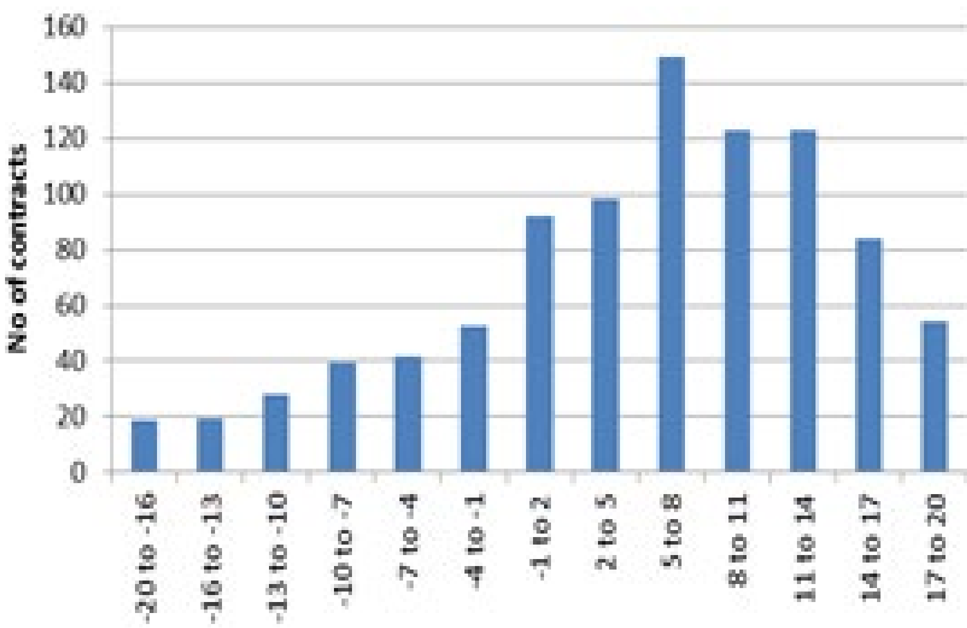
A prospective contract is entered in the Contract Status Ledger. If it is decided that the company should proceed with the contract and all the legal agreements have been concluded with the client, the Bill of Quantities (BOQ) for the contract would be imported into the *Valuations* module. The BOQ contains all the items of work required to be completed. As the work commences on the contract, the QS in charge of the contract, would update the BOQ items in terms of percentage complete. Using this information, the QS would bill the client using Contract Sales Ledger certificates. The client themselves will employ a QS, known as a Principal Quantity Surveyor (PQS) who will inspect the claims from the QS to determine the payment made to the agribusiness construction company. The amount claimed for and amount received will be stored on the certificate in Contract Sales Ledger. This will update the revenues of the contract.

As the work on the contract progresses, *Procurement* would be used to place orders from the selected suppliers, which would automatically update the costs of the contract. *HR & Payroll* will be used to pay the workers on the contract, and these modules will also update the costs for the contract. For work that is done via subcontractors, orders will be placed via *Subcontract Ledger*. The subcontractor will follow a similar system for the work obtained. The subcontractor will then bill the agribusiness construction company for the work completed via subcontract certificates in the Subcontract Ledger. The subcontract certificate will contain both the applied-for amount by the subcontractor and the actual amount paid to the subcontractor. This module will also update the costs for the contract. At monthly or quarterly intervals, the QS will complete a Cost Value Reconciliation (CVR), which amongst other things contains the QS's forecasts for future costs and revenue for the contract. These values are loaded into the Contract Status Ledger for forecasting. The *Financials* module will retain a summary of all the costs and revenues for the contract. The reporting can be done at sub-contract, contract, group, or company level.

Methods

Data Set: The data set was extracted from the live financial data, and restricted to completed contracts which are upwards of a hundred thousand US dollars equivalent in costs incurred. The total number of contracts available in the data set is 934. Figure 2 displays the range of profit percentages. The distribution is skewed to the right, indicating that the number of contracts that were profitable is greater than the number of contracts which were loss-making. Approximately 40% of the contracts are in the 5% to 14% profit range, which is an encouraging news for this sector.

Figure 2: – Profits in agribusiness construction contracts.



Extraction and Setup: Contracts below and above the -20% to 20% profit were rejected as outliers. The contract data is extracted from the live system by performing a database dump of table jc_job into a database dump-file. The dump-file is then used to create table jc_job of the same structure as the live system in a locally accessible database. Financials and Contract Status Ledger reports are run to extract the final cost incurred and revenue received for all the completed contracts. In the local database, fields prj_cost, prj_rev, prj_profperc are created on table jc_job. An index is created on table jc_job containing the following fields (in ascending order): job_complete, prj_cost, job_num. The cost and revenue data extracted from the reports are loaded into the new jc_job fields, and profit percentage is calculated from cost and revenue. Since all the data is now in one database table, we can run a simple Progress queries on the contracts of interest, as follows:

```
for each jc_job no-lock where
        jc_job.kco = 1 and
        jc_job.job_complete and
        jc_job.prj_cost >= dMinCost and
        jc_job.prj_rev > 0 and
        (jc_job.prj_profperc >= dMinProfitPerc and
        jc_job.prj_profperc <= dMaxProfitPerc):
        /* code */
end.
```

By specifying job_complete and prj_cost in the query, the new index created in step 5 above is automatically invoked, and as a consequence, even though the database table jc_job contains a very large number of contracts, the completed contracts of over certain cost incurred, which are of interest to us, are retrieved very efficiently.

Contract Attributes: A contract entered in Contract Status Ledger, has several attributes which will serve as our predictor variables. 10 attributes were chosen some of which may be extremely relevant toward contract profitability, whereas others may be completely irrelevant. Though we may have some prior knowledge or an intuition about which attributes will be relevant, we will not encode this information into the system; instead we will test the predictions of the system against our prior knowledge. All the attributes are nominal multinomial, i.e. the values are alpha-numeric codes which cannot be ranked. The breakdown of these attributes is presented in Table 1. The attributes extracted from the contracts are set when the prospective contract is input, and are not changed once the contract has commenced. While the suppliers and subcontractors used while the contract is underway may contribute to the contract profitability, since we are making the contract profitability prediction of a prospective contract these operatives do not figure in our calculations.

Table 1: Contract attributes

Number	Name	Description	Unique values
1	jcl_loc	The location of the contract	29
2	jgr_grp	The group within the company undertaking the contract	8
3	job_anl[1]	Attributes are used by agribusiness companies to enter information of their choosing. This could be for accounting or reporting purposes, or could be information like Group/Regional Manager	53
4	job_anl[2]		79
5	job_anl[3]		72
6	job_anl[4]		46
7	job_arc	The architect used for the contract	36
8	job_qsr	The QS in charge of the contract	92
9	jty_typ	The contract type. This could be revenue type, e.g. cost-plus or Pain/Gain, or could be another way of classifying contracts	31
10	rcm_num	The client for the contract	265

Attribute Combinations: Apart from the main goal of making predictions on contract profitability, we also need to identify the attributes which contribute towards contract profitability. Possible combinations of the 10 attributes are:

$$ {}_{10}C_1 + {}_{10}C_2 + {}_{10}C_3 + {}_{10}C_4 + {}_{10}C_5 + {}_{10}C_6 + {}_{10}C_7 + {}_{10}C_8 + {}_{10}C_9 + {}_{10}C_{10} $$

$$ = 10 + 45 + 120 + 210 + 252 + 210 + 120 + 45 + 10 + 1 = 1023. $$

Cross-Validation: The experiments were done using 10-fold cross-validation which is commonly used (Bengio & Grandvalet, 2004). The data is partitioned into 10 subsamples. Of the 10, each one in turn is used as test set and the other 9 as the training set. Leave-one-out cross-validation is not used due to the fact that it would prove to be computationally extremely expensive. However, we cannot divide the contracts into 10 subsamples as extracted from the database table. This is due to the fact that contract name is in the table index, which implies that contracts will appear in ascending alpha-numeric order. This could be a potential problem if similar contracts have similar names. In this case, we may end up with the scenario that contracts within each subsample may be very similar to each other but very different to contracts in another subsample. To overcome this difficulty, we pick contracts at random into the subsamples with the following algorithm:

```
define temp-table ttJob with fields i, and name indexed by i
define temp-table ttFold with fields iFold, and name indexed by iFold and name.
set total = 0 & folds = 10.
loop through all contracts filtered by cost and profit percentage increment total.
create an entry in ttJob with ttJob.i = total & ttJob.name = contract name.
end loop
set foldsize = floor(total / folds).
loop variable i from 1 to (folds – 1)
        set j = 0.
        repeat until j < foldsize
                set x = random integer between 1 and total
                find ttJob where ttJob.i = x.
                if found ttJob
                        create an entry in ttFold with ttFold.iFold = i & ttFold.name =
                        ttJob.name.
                        delete record from ttJob.
                        increment j.
                end if
        end loop
        set total = total – foldsize.
        set j = 0.
        loop through all ttJob
                increment j.
                set ttjob.i = j.
        end loop
end Loop
```

loop through all ttJob

create an entry in ttFold with ttFold.iFold = folds and ttFold.name = ttJob.name

end loop

export ttFold to text file for future use.

Vector Space Model (VSM): To make predictions about the profitability of a prospective contract, we can start by making an assumption that similar contracts will have similar profitability. For example, a contract to demolish an unused office building and to clear the area in a given location, managed by quantity surveyor QS1 and Regional Manager RM1 should be similar in profitability of another contract of the same type of work and managed by the same people which is undertaken a few months later, since the type of work, location of work, and the personnel involved are the same.

To find similar contracts to a prospective contract, we use the VSM which is used to rank or classify textual documents in Information Retrieval. VSM is based on linear algebra and converts documents into vectors of index terms. One of the measures used to identify similarity is cosine similarity, which measures the angle between two vectors of *n* dimensions (Singhal, 2001). Given two vectors A and B, the cosine similarity is given by their dot product and magnitude:

$$\mathrm{Cos}(\theta) = A \bullet B \,/\, \| A \| \, \| B \|$$

In information retrieval the document vectors would be represented by TF-IDF (Term Frequency – Inverse Document Frequency) which is one of the most commonly used statistical weighting schemes in today's information retrieval systems to evaluate how important a word is to a document or a corpus (Aizawa, 2003). However, in our case this is not required or applicable since each contract attribute can take only one value, and hence each contract can be represented as a vector containing attribute values, whose maximum length can be only 10. (While performing cosine similarity, normalizing by magnitude is required, as there exists a possibility that a particular attribute may not be set – i.e. blank/unknown value - on the contract).

The system calculates the top most similar contracts for the one we're trying to predict, and takes the average profitability of all the calculated similar contracts as the prediction. All the 1,023 attribute combinations are processed and predictions made for every contract using 10-fold cross validation. The best three and the worst three predictions are listed in columns 2 to 4 of table 2.

Table 2: VSM and KRR results

Rank	VSM			KRR			
	Fields	Mean Absolute Error	Median Absolute Error	Fields	Mean Absolute Error	Median Absolute Error	λ
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Best results							
1	jcl_loc, jgr_grp, job_anl[4], jty_typ, rcm_num	5.68	4.76	jcl_loc, jgr_grp, job_anl[4], jty_typ, rcm_num	5.01	4.13	0.1
2	jcl_loc, jgr_grp, job_anl[4], job_qsr, jty_typ, rcm_num	5.73	4.79	jcl_loc, jgr_grp, job_anl[4], job_qsr, jty_typ, rcm_num	5.07	4.17	1
3	jgr_grp, job_anl[4], job_qsr, jty_typ, rcm_num	5.80	4.85	jgr_grp, job_anl[4], job_qsr, jty_typ, rcm_num	5.09	4.19	0.1
Worst results							
1021	job_anl[1], job_anl[3]	7.13	5.90	jgr_grp, job_anl[1], job_anl[2], job_anl[3], job_arc, job_qsr, rcm_num	7.81	5.79	0.01
1022	jgr_grp, job_anl[1], job_anl[2], job_anl[3], job_arc	7.19	5.92	jcl_loc, jgr_grp, job_anl[1], job_anl[2], job_anl[3], job_anl[4], job_arc, job_qsr, rcm_num	7.97	5.85	0.01
1023	job_anl[2]	7.31	5.95	job_anl[1], job_anl[2], job_anl[3], job_anl[4], job_arc, job_qsr, rcm_num	7.97	5.87	0.01

The error distribution of the best attribute combination is shown in Figure 3a.

Figure 3: Error distribution using various methods

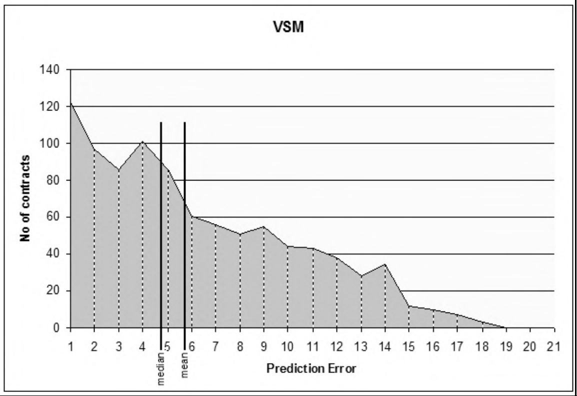


Figure 3a: – Using VSM

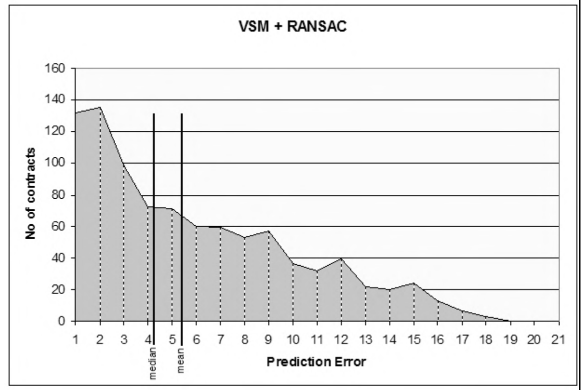


Figure 3b: – Using VSM and RANSAC

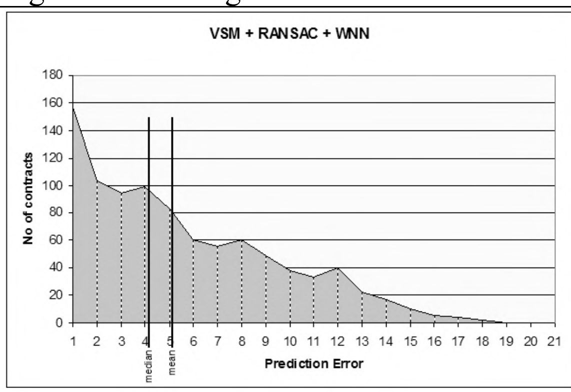


Figure 3c: Using VSM, RANSAC and WNN

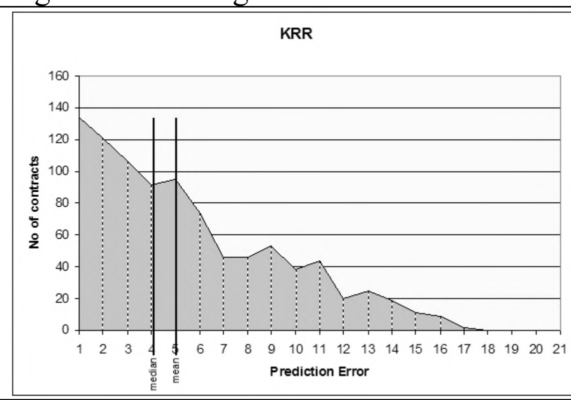


Figure 3d: Using KRR

Outlier Elimination: There are many approaches to dealing with outliers (Barnett & Lewis, 1994). Detection of outliers is more problematic as the classic estimates of the mean and covariance matrix using all the data are extremely sensitive to the presence of outliers (Todorov et al., 2011). Mahalanobis distances provide the standard test for outliers in multivariate data in case of normal distribution. However, the performance of the test depends crucially on the subset of observations used to estimate the parameters of the distribution (Riani et al., 2009). To identify outliers we use Random Sample Consensus (RANSAC) which is an iterative method of eliminating outliers by iteratively selecting a random subset of the given data as hypothetical inliers to calculate the true outliers of the data. The system calculates the top most similar contracts for the one we're trying to predict, performs outlier elimination and takes the average of the remaining inliers as the predicted profitability. The predictions are made by the system for every contract using 10-fold cross validation. Prediction error is shown in Figure 3b. The mean absolute error is 5.41 and the median absolute error is 4.28.

Weighted Nearest Neighbour: Performing outlier elimination on the results of Vector Space Model improves both the mean and the median absolute error. We know that the profitability of the majority of contracts lies in the 5% to 8% range (Figure 2). We use this knowledge by weighting the contracts which fall in this range higher than other contracts. Instead of taking the mean of the remaining inliers, we take the weighted mean:

$$\Sigma w_i x_i / \Sigma w_i$$

The system calculates the top most similar contracts for the one we're trying to predict, performs outlier elimination and takes the weighted mean of the remaining inliers as the predicted profitability. The predictions are made by the system for every contract using 10-fold cross validation and weighted nearest neighbour (WNN) are shown in Figure 3c. The mean absolute error is 5.09 and the median absolute error is 4.17.

Kernel Ridge Regression (KRR): A system with weights trained by regression can then be used to make predictions. Linear regression attempts to find a linear relationship:

$$Xw = Y$$

while the optimal value of weight w can be found using Ordinary Least Squares:

$$w = (X^T X)^{-1} X^T y$$

Ridge regression is useful when $(X^T X)^{-1}$ does not exist or inversion is numerically unstable. A problem that often arises in regression is overfitting when the model describes noise instead of the underlying relationship. One of the common techniques to combat this issue is to introduce a regulariser (λ). This acts as weight decay, as in a sequential learning algorithm, it encourages weight values to decay towards zero, unless supported by data. With L training examples, the optimal value of weight vector with dimension n of the feature space can then be found as:

$$w = (X^T X + \lambda I_n)^{-1} X^T y$$

$$w = \lambda^{-1} X^T (y - Xw)\ X^T y = X^T \alpha$$

$$w = \Sigma \alpha_i x_i$$

$$\alpha = (X^T X + \lambda I_L)^{-1} y$$

and the prediction function can be given by:

$$\langle w, x \rangle = \Sigma \alpha_i \langle x_i, x \rangle$$

Indicator Variables and Kernel Functions: Since all our predictor variables are nominal multinomial, we need to transform them into binary indicator variables for regression. The procedure creates a separate file for each attribute. When the regression system that is processing the data comes across a particular combination of attributes, it horizontally concatenates the files corresponding to the attributes in the combination being processed:

$$\phi : D \rightarrow F, K(d_i, d_j) = \langle \phi(d_i), \phi(d_j) \rangle$$

To construct the Kernel, we will try to replicate Vector Space Kernel, where the Kernel is term-document matrix (D) multiplied with its transpose:

$$K = DD^T$$

The term-document matrix contains the term frequencies. In our case, the Kernel matrix will be the indicator variable matrix multiplied by its transpose.

Regression: All the attribute combinations are processed with varying values of λ. A prediction is made for every contract using 10-fold cross validation. The results for the best three and the worst three predictions are listed in the last four columns of table 2. The error distribution of the best attribute combination is shown in Figure 3d.

Results

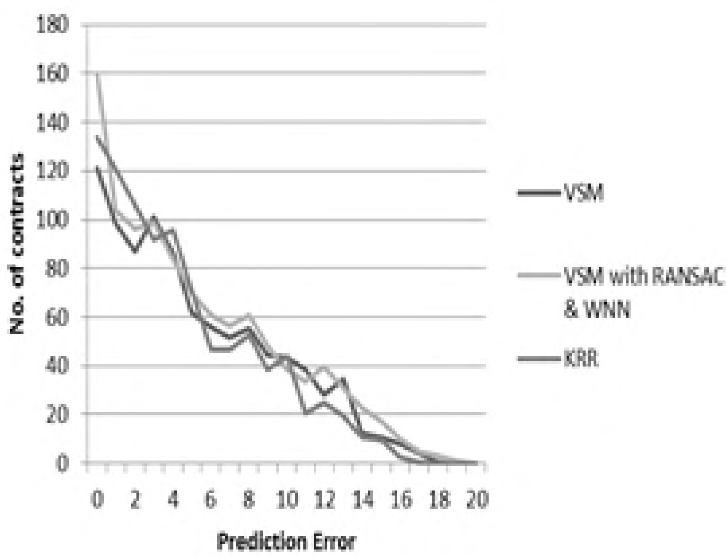
Table 3 shows results of the experiments performed by Vector Space Model and Kernel Ridge Regression the results are broadly similar. The results for KRR are slightly better than VSM when enhanced with outlier elimination and weighted nearest neighbour, but not significantly so.

Table 3: Performance comparison

Method	Mean Absolute Error	Median Absolute Error
Vector Space Model	5.68	4.76
Vector Space Model & outlier elimination	5.41	4.28
Vector Space Model, outlier elimination, & weighted nearest neighbour	5.09	4.17
Kernel Ridge Regression	5.01	4.13

Figure 4 shows the error distribution of KRR plotted against error distribution of VSM, and enhanced VSM.

Figure 4: Error distribution of VSM enhanced VSM and KRR



The most encouraging result from implementing both VSM and KRR is the fact that they both give their best result on the same attribute combination and their top 3 attribute combinations have the same attributes as evident in column 2 and 5 of tables 2. The fact that they perform badly on different attribute combinations, is of no relevance. We can thus make a decision on which attributes contribute towards profitability and which have no effect. The attributes that influence contract profitability are: location, group, manager, QS, contract type, and client.

Conclusion and further work

As agriculture turns to agribusiness around the world, the role of agribusiness construction is increasing. The paper presents a Machine Learning approach to prediction of profitability in agribusiness construction contracts of public enterprises. The estimation of a prospective contract's profitability need not be done by intuition or by political considerations. A mathematical model to aid in predicting the profitability of a prospective contract would be of immense use to public enterprises to ward off political pressure. Furthermore, it would of considerable interest to commercial managers to know the effect on predicted profitability of a contract should they change the value of an attribute of a prospective contract. Both the VSM and KRR routines are fairly simple to implement in a commercial setting. Application in public enterprises will require close interaction between scholars in the field of agricultural sciences, computer science and business.

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Mergers and Acquisitions: Implications for public enterprises in developing countries

Saran S. Singh
Independent researcher, India
saransaket63@gmail.com

Abstract

For more than a century, regulatory intervention in corporate mergers and acquisitions has been of much interest to corporate strategists. The high level of merger and acquisition activity across the world over the three decades of a century has revitalised the field of Industrial Organisation (IO). This has accelerated in the public sector of developing countries like India. For policy formulation, the antitrust authorities are increasingly relying on research in this field to comprehend the factors that affect how firms and markets are organised and behave. However, there hasn't been any analysis to determine whether the authorised mergers are anti-competitive. IO is a high-tech, high-brow field of research because to the employment of increasingly complicated models, but its theoretical suitability, empirical validity, and policy usefulness have not yet been determined. This paper examines the research models and procedures utilised in current IO research and comes to the conclusion that a more rigorous analytical framework is required to give IO studies credibility. In case of Public Sector Enterprises, collusive behaviour is not a problem, but there is a need to look at other areas of concern.

KEYWORDS: Mergers, acquisitions, industrial organisation

Introduction

High level of merger and acquisition (M&A) activity over the past quarter of century has revitalised the field of Industrial Organisation (IO) which is concerned with determinants of firm and market organisation and behaviour. In developing countries, M&A is affecting public enterprises as well (Sangisetti, 2022). Time has come that the regulators in developing countries and researchers in the field of public enterprises understand the theory and practice of IO that relates to M&A

In the seventies, the field of IO was preoccupied with analysis across industries. Its advancement was slowed by a lack of fresh theoretical understanding and an inability to locate data to address current pressing issues, and it was becoming clear that the field was not heading in the right direction. (Fuchs, 1972). Pre-1980 literature had been so nontheoretical, or even antitheoretical, that few economic theorists were attracted to it. In the eighties its research agenda moved toward analysing individual industries and boundaries of the firm. "Market structure" became an old-fashioned term in IO and the general Structure-Conduct-Performance (SCP) paradigm that made links between structure and performance was forgotten. Questions about the global organisation of production in the economy were ceded to other branches of economics like trade and macroeconomics. Application of game theory and better data accessibility and utilisation elevated IO.. Oliver Williamson (1996) announced IO as "the queen of microeconomics" and insisted that M&A "will continue to be its main beneficiary." (p. 306).

IO has donned the mantle of a high-tech discipline. Moreover, its users, - the law makers and antitrust authorities across the globe seem to be content by the work they are doing. For example, the report of the US Antitrust Modernization Commission declares that relevant U.S. antitrust laws are 'sound' and that U.S. antitrust enforcement has attained an appropriate focus on (1) fostering innovation; (2) promoting competition and consumer welfare; and (3) aggressively punishing criminal cartel activity. As far as between-industry differences are concerned, the US Antitrust Modernization Commission reported in 2007 that it does not believe that new or different rules are needed to address so-called "new economy" and insisted that the antitrust laws remain relevant in today's environment and tomorrow's as well. Further the Commission submitted that differential treatment to different industries is unnecessary. The economists are less sanguine and many feel that the current state of IO research there is inadequate attention to applied work on measurement based data that continues by framing the empirical exercise in terms of a coherent economic model. Significant public resources are devoted to the review of the potential anticompetitive effects of mergers before they are approved. Yet there has been little evaluation of whether or not the mergers that have been permitted are anticompetitive. Without this information analysis of government policies is hardly possible (Ashenfelter & Hosken, 2010). Crandall and Winston (2003), for example, argue that antitrust policy has not been favourable to the consumers, while in the same issue of *Journal of Economic Perspectives* Baker (2003) expresses opposite views. If IO is to guide antitrust policy and practice, it should concentrate on how prior business mergers affected consumer pricing. This is not being done. While in the field of labour economics, one can find hundreds of empirical studies on how wages are affected by unionisation, minimum wage laws etc., research on the aggregate effects of merger policy is limited (Angrist & Pischke, 2010).

The basic approach of the econometric industry studies has been called 'new empirical industrial organisation' (NEIO). The methodology of initial studies under this approach lacked sophistication (Bresahan, 1989). Behavioural interpretations were assigned to 'conjectural variations' These were then utilised as a measurement of market power (Corts, 1999). To circumvent assessment of several cross-elasticities in these studies, solid restrictions on demand function were applied. Endogeneity of prices and quantities and other identification problems were not considered at all. During the late 1990's better techniques were established under the brand of 'structural IO' (Ackerberg et al, 2007; Reiss & Wolak, 2007). Demand system is typically estimated by means of discreet choice models of product differentiation (Berry, 1994). Nested demand structures that impose restrictions on substitution effects between brands in different segments have been developed. Demand modelling has focussed on the trade-off between allowing flexible substitution patterns and the lack of disparity in representative data that allows such substitution patterns to be identified flexibly. Demand elasticities are identified using instrumental variables like prices in other markets. Thereafter, a model of market behaviour is formulated using the substitution matrix enabling simulation of conduct of the industry with merger and without. These models have removed low-brow low-tech stigma from IO but their credibility is in question.

Industrial Disorganisation

Mergers in the ready-to-eat cereal business is an important example as it could affect the price of a popular consumer food product. It is one of the most recession-resistant product because of its low cost. The products in case of cereal industry are closely related but not identical (Hausman, 1997). Moreover there is differing levels of similarity across cereal brands. One strategy could be to divide products into segments and estimate a model that restricts substitution patterns across segments but allows flexibility within segments. In the new models developed under NEIO and structural IO (Baker & Bresnahan, 1985), 'front-end' estimation of the structural parameters computes demand functions and supply relations. Thereafter, these estimates can be used to simulate post-merger equilibrium in the 'back-end' analysis.

Models with nonlinear demand, multi-product producers, economies of scale and heterogeneous products can produce an even wider range of results. In these complicated but relevant models, whether or not mergers re profitable and/or socially desirable can vary a lot across parameter values (Berry & Pakes, 1993). Aviv Nevo (1997, 2000, 2001) tried to measure market power and implications of mergers in ready-to-eat cereal industry painstaking empirical work. Assumptions made are of some concern. The demand system formulated imposes restrictions on substitution patterns which are unconvincing. Instrumental variables are notoriously hard to discover and. Prices in other markets can be used as instrumental variables if the assumption of independence across markets holds, which appears arbitrary. It has been implied that the mergers affect prices through only one channel, i.e., the decrease in the number of competitors. This is implausible as the prices can be affected by other factors like cost reductions. Comparable difficulties plague structural models of airline mergers. Supply-side effects, such as variations in marginal costs or deviations from the assumed model of firm behaviour are hard to integrate in the model intended to estimate the result of the alteration in ownership and management on unilateral pricing incentives. Analysis consolidation in the airline industry of the 1980s by Craig Peters (2010) reveals that the structural analyses of these mergers do not yield accurate predictions of the ticket prices after the mergers. He recommends that the future research could use more flexible models of firm behaviour.

Utilizing the difference-in-difference (D-in-D) technique and imagining a scenario in which the merger had not taken place is an alternative. The assignment of participants to the treatment group and the comparison group cannot, of course, be random, but it can be supposed to be 'as if random'. Ashenfelter & Hosken (2010) used this methodology to examine mergers in cereal industry and state: "It is unclear why Nevo's predictions are so different from our estimates" (p. 450). Hastings (2004) used this method to assess the pricing implications of Thrifty by ARCO's acquisition of a gas retailer on a panel of station-specific prices including the station-level fixed effects and the city-time effects. Whereas Nevo's framework is an intricate set of equations wherein it is hard to find out what is driving the result, D-in-D results come from a simple equation showing the mean change resulting from the treatment. A simplified Hasting's equation to find the price p at time t at station i is:

$$p_{it} = \mu + \alpha_i + \delta\gamma \bullet t + \theta z_{it} + \varepsilon_{it} \tag{1}$$

where μ is constant and α_i is time-invariant station-specific deviation from μ. γ is city dummy. z_{it} is an indicator of competition with independent station. The coefficient θ indicates whether the presence of an independent competitor affects the local selling price.

This analysis seems to have a flaw in that it only considers the effects of a merger on Thrifty's rivals, not the former Thrifty stations. As the expected effect was five cents per gallon, it meant that the retail margins would increase by a whopping 50 percent. However, other researchers (Taylor et al., 2010) used the same dataset and presented the results of the following regression:

$$p_{it} = \mu + \alpha_i + \beta\ Convert_{it} + \Sigma_j \Sigma_k \delta^{jk} \gamma_i \tau_t + \varepsilon_{it} \tag{2}$$

where the dummy variable $Convert_{it}$ takes a value of one if station i is located within a mile of a Thrifty station during period t. Thus, a negative β suggests that the loss of an independent competitor is correlated with a rise in the average price at these competing stations. The city-time fixed effects are captured by the interaction of city dummies, γ_i and time dummies τ_t. The coefficient estimates of the variable of main interest, i.e., *Convert* are quite different. In short, the increase in the price was found to be just one fiftieth of that found by Hastings. This finding holds even in case of when various sub-samples and the authors are not convinced that ARCO's acquisition of Thrifty resulted in higher prices. While Hastings's research finds support for the underlying model of consumer preference, Taylor et al. doubt whether this model depicts consumer behaviour and disagree with the underlying model of consumer preferences. With time, D-in-D methodology is becoming more and more sophisticated; but it faces the charge that it is atheoretical and sensitive to assumptions.

Trusting antitrust

If we can trust neither the structurally derived estimates nor direct D-in-D estimates, what do we do? With time, structural models are probably going to get more complex. It's unclear whether they will be able to rely on fewer, more believable hypotheses. According to randomistas, several structural models should be tested, and the one that best fits the direct estimates should be used. In keeping with this, Hausman and Leonard (2002) used three structural models in their investigation of new toilet paper brands and found that the Nash-Bertrand model which is frequently employed in studies of the competitive effects of mergers yield indirect estimates reasonably similar to the direct estimates and superior to the indirect estimates produced by the two alternative models they tried. This raises the issue of whether direct estimates represent the gold standard. DD estimates cannot be trusted, as demonstrated in the case study of ARCO's acquisition of Thrifty gas stations. Many renowned scholars have criticised the focus on experimental or quasi-experimental outcomes on theoretical grounds. For example Nobel Laureate James Heckman (2010) points out that economic choice theory has been abandoned in favour of statistics. The crucial distinctions between subjective and objective evaluations and ex ante and ex post outcomes, which are at the heart of structural econometrics, are lost. Finally, even if we are able to draw some credible conclusions from private sector mergers in the past, how relevant are these estimates to future mergers involving public enterprises?

Merger analysis bring forward unusual problems in case of merger of a public enterprise with a private one. Although considering stock prices and balance sheets is not difficult, understanding the cultural environment is challenging. For example, there are significant differences between human resource management practices and management of external environment. In case of public enterprises, the decisions also need to be politically acceptable and socially desirable. The decentring of the state as a result of globalisation, neo-liberalism and developments in legal theory and methodology has had a destabilising influence on M&A theory and practice and a lot of theoretical and empirical research is necessary.

Conclusion

M&A literature has not kept pace with theoretical advancements pertaining to the sources of value creation for firms (Feldman & Hernandez, 2022). Regarding the precise role that organisation should play, economic theory has not said much. On the other hand, business school non-economists typically believe that organisation matters and that firms are not, despite what economic theory may posit, undifferentiated profit maximising agencies that respond to specific market situations in ways that are independent of their organisation. The merger policy has been the most significant area of public action relating to market structure that IO economists have sought to inform. As a result of the influence of IO scholars as compared to that of lawyers and jurists (White, 2010), the United States' stance toward horizontal mergers has greatly advanced since the first Guidelines were published in 1968 (Shapiro, 2010). Other countries can learn from this evolution. The primary structural indicator taken into consideration is no longer market shares. If there is no change in the nature or level of competition, unilateral effects—the performance impacts of changing the structure—are viewed as being more significant. The 2010 Guidelines provide a considerably more in-depth analytical approach that is based on theoretical developments and enforcement experience rather than empirical data. Coordinated effects - adverse changes in (expected) market performance that occur because changes in market structure make collusive behaviour more likely – have been put in the background as the tools available to analyse unilateral effects have become much more powerful (Schmalensee, 2012). Merger simulation models formulated by Budzinski and Ruhmer (2010) can be employed to integrate information from a variety of sources, and the newly introduced Upward Pricing Pressure (UPP) test is an improvement over the traditional market definition approach in case of differentiated products. But these new tools shed no light whatever on coordinated effects. Merger simulation models usually assume single-period Bertrand competition and the UPP test assumes that the demand curves facing the merging firms do not change as a consequence of their merger or their post-merger price changes (Jaffe, & Weyl, 2013). As a discipline, M&A has rebuilt itself many times in the past; to maintain its relevance, it needs to reinvent itself once more. A relevant and coherent rebuilding of the discipline relevant to the public sector enterprises will depend on its ability to take new developments into account. The models will need to incorporate political imperatives and social obligations..

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Measuring Energy efficiency in public enterprise: The case of Agribusiness

Victoria C. M. P. Bou
Independent researcher, Australia
vcmpbou@gmail.com

Abstract

Public sector enterprises claim to be more socially conscious than their counterparts in the private sector. Often it is touted as the main justification for their existence. Public sector has taken a lead in enhancing energy efficiency not just for profitability but also for environmental concerns. Measurement of energy efficiency, however, presents a plethora of challenges. Adding on of social concerns to environmental challenges has widened the scope of sustainability beyond a buzzword. Recent advances in Data envelopment analysis show how measurement can be done reliably.

KEYWORDS: Energy efficiency, sustainability, technical efficiency, allocative efficiency

Introduction

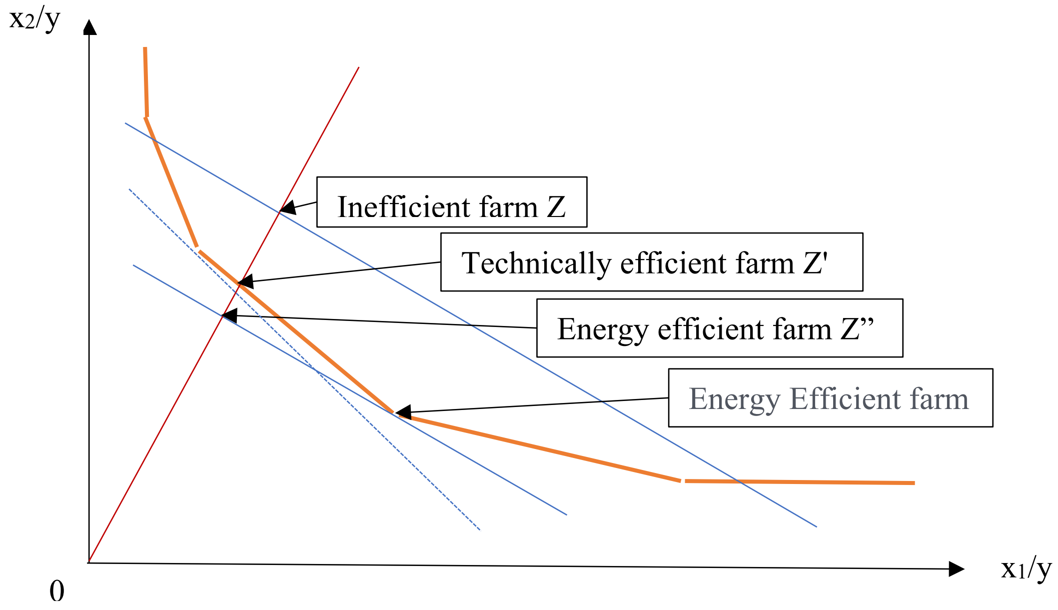
Agriculture is one of the few industries that creates resources repetitively from nature in a sustainable way by creating organic matter and its derivatives by utilizing solar energy and other materials in nature. Agribusiness is an energy consuming sector and it is also an energy producer through bioenergy. Modern agribusiness applies scientific principles for the optimal conversion of natural resources into agricultural land, machinery, structure, processes, and systems for increasing productivity. Increases in crop productivity achieved 1960s onwards in Latin America are attributable to advances in sciences and the significant use of fossil fuel-powered farm equipment and machinery, intensive tillage, irrigation and chemical inputs. Between 1980 and 2012, regional agricultural output per worker increased by 82 per cent and total factor productivity increased by 45 percent (Nin Pratt et al., 2015). This improved performance of agriculture was the result of fast growth in the use of fertilizer, increases in land productivity, and growth in the use of capital that expanded cultivated area per worker (Martin-Retortillo et al., 2022). As agriculture transforms itself from a subsistence activity to agribusiness in Latin America, it has become increasingly reliant on chemical fertilizers derived from fossil fuels, natural gas and diesel-powered machinery. Storage, processing and distribution of agricultural produce are also often energy-intensive activities (Moreno-Moreno et al., 2018). There is significant uncertainty concerning the price and availability of energy needed to power farm operations and produce key inputs, like irrigation and fertilizers. This uncertainty jeopardizes future productive potential and reduces productivity of inputs. Higher energy costs, therefore, have a direct and strong impact on profitability in agribusiness. High-input, energy-intensive agriculture has been called a product of knowledge applied before giving consideration to its full ecological and social costs (Orr, 1996). While the importance of energy efficiency in the sector is being increasingly examined, economic and cultural barriers in Latin American societies hinder the full application of energy enforcement standards and a lack of human resources (caused by budgetary constraints) means that monitoring and enforcement systems are inefficient (ECLAC, 2014). Availability and quality of data is a major constraint [IEA]. Decision makers are generally hesitant to act in the absence of accurate data. This paper seeks to propose a way to measure energy efficiency in agriculture in a cost framework in presence of uncertainty.

Technical efficiency and allocative efficiency

The terms "energy conservation" and "energy efficiency" are often used interchangeably, but are different. Energy conservation means using less energy and is usually a human behavioural change; energy efficiency, means using energy more effectively, and is mainly a technological change. Energy efficiency is commonly denoted as outputs and inputs converted to energy. The most basic definition of energy efficiency derives from the first-law of thermodynamics and measures the ratio of ‘useful’ energy outputs to the heat content, or calorific value of fuel inputs (Berndt, 1978). Overall productive efficiency is commonly defined as a product of technical efficiency and allocative efficiency (Farell, 1957). The allocative efficiency measures a producer’s success in choosing an optimal set of inputs with a given set of energy contents in inputs; this is distinguished from the technical efficiency concept associated with the production frontier, which measures success in producing maximum output from a given set of inputs. Not all farmers can utilise the minimum inputs required to produce the outputs they choose to produce, given the technology at their disposal. In light of the evident failure of at least some producers to optimize, it is desirable to recast the analysis of production away from the traditional production function approach toward a frontier based approach. Hence we are concerned with the estimation of frontiers, which envelop data, rather than with functions, which intersect data (Daraio & Simmer, 2007). For measuring and decomposing energy efficiency, we use linear programming to construct a non-parametric frontier.

In figure 1 segmented orange line is the technically efficient frontier when there is one input (y) and two inputs x_1 and x_2. On the radial line, 0Z'/0Z gives the technical efficiency of farm Z. If the energy content of inputs x_1 and x_2 are known we can draw iso-energy lines which are in blue. The lowest iso-energy line touching the technically efficient frontier is relevant for our purpose of energy efficiency. Z' in figure 1 is technically efficient but not allocatively efficient. We derive the relationship 0Z"/0Z = (0Z'/0Z) X (0Z"/0Z').

Figure 1: Measurement of technical efficiency and allocative efficiency



The measurement of energy efficiency requires assessment of direct and indirect energy content of each input which is a contentious issue. The most common technique of measurement is Life Cycle Energy Assessment (LCEA) which was earlier called energy analysis (Hammond, 2004). In this method all energy inputs to a product are accounted for - direct energy inputs during manufacture as also all energy inputs needed to produce components, materials and services needed for the manufacturing process. A problem this method cannot resolve is that different energy forms have different quality and value even in natural sciences, as a consequence of the two main laws of thermodynamics. According to the first law of thermodynamics, all energy inputs should be accounted with equal weight, whereas by the second law diverse energy forms should be accounted by different values. With LCEA, the total life cycle energy input is established by ignoring value difference between energy inputs or assigning an arbitrary value ratio (e.g., a joule of electricity is 2.6 times more valuable than a joule of heat or fuel input). Rigid system boundaries make accounting for changes in the system difficult. This is sometimes referred to as the boundary critique to systems thinking. Data from generic processes may be based on averages; whereas in case of many products the manufacturers refuse to give complete information claiming it to be a trade secret. A critical review of the approach revealed a large number of examples from the literature where difficulties in obtaining reliable data defining the boundary systems were tackled by accepting controversial, incomplete, and inappropriate data (Zegada-Lizarazu et al., 2010)

To compute energy efficiency when knowledge of exact energy content of inputs is not known we consider another scenario when iso-energy lines have different slopes. The lowest of these lines, a dotted blue line in figure 1, touches the segmented frontier line at a different point – a farm that uses x_2 more than x_1. This is so because under the new scenario ratio of energy intensity of x_2 and energy intensity of x_1 is lower. Though technical efficiency of the farm Z remains the same, its allocative efficiency and therefore energy efficiency in this scenario is higher.

Data was collected in a survey of 21 public sector banana plantations in Latin America. Banana, the world's most popular fruit, is a tropical fruit that grows best at latitude 20 degrees north and south of equator. Ecuador and Colombia are the top two suppliers of banana to the European Union. The banana market is characterized by heavy horizontal and vertical integration within the value chain and a low-cost and highly competitive export market focused in Latin America. Bananas are typically grown on plantations, and certain viruses, pests and fungi have spread in epidemic proportions over the last few decades, allegedly a result of decreased immunity created by monoculture practices (Mlot, 2004). Increased susceptibility has rendered banana plantations increasingly dependent on agrochemicals with high energy content. In turn, the extensive use of agrochemicals has given rise to the emergence of pest strains that are resistant to pesticides, posing a problem to plantation managers seeking to reduce agrochemical use (Liu, 2009). Energy content of input available from the manufacturers and in the literature varies widely Minimum and maximum reasonable values were recorded from the studies in Denmark (Dalggaard et al., 2001), Baluchistan province of Iran (Amini & Ravandeh, 2015), Hamedan province of Iran (Mobtaker et al., 2010), Haryana, India (Singh, 2002) and Turkey (Akcaoz, 2011; Barut et al., 2011; Hatirliet al., 2005) These values and the averages are given Table 1.

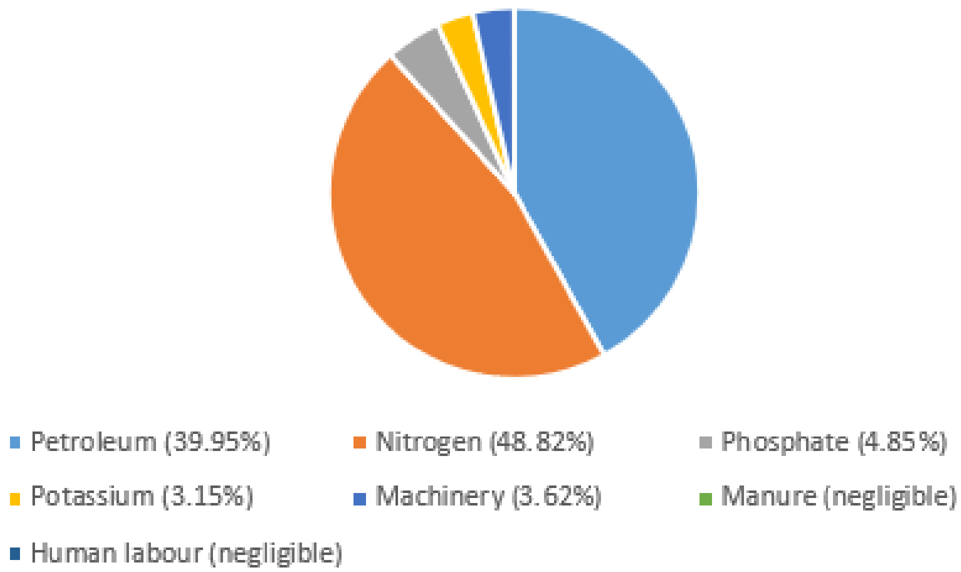
Table 1: Energy content of inputs in MJ per unit.

Input	Unit	Maximum	Minimum	Average
Diesel	litre	51.5	35.9	47.8
Machinery	hour	158.30		62.7

Nitrogen	kilogram	78.2	12.6	54.6
Phosphate	kilogram			9.9
Potassium	kilogram			9.1
Manure	ton			7.9
Labour	hour	1.9	0.2	0.3

The energy required for all farms with regard to five inputs, farmyard manure, chemical fertilizers, diesel fuel, machinery and human labour was calculated. The average of total input energy were found **as 50026 MJ per hectare**. As shown in Fig. 2, the amounts of nitrogen and fuel with just under 49% and 40% respectively had the maximum share among all input energy used in banana production. While the share of other chemicals (Phosphorus and Potassium) and of machinery was significant, the share of farmyard manure and human labour was negligible testifying the dependence on chemicals in modern agriculture.

Figure 2: Energy required for inputs



To examine energy efficiency in the deterministic case, we run the linear programming models following Färe et al. (1985) under the assumptions of constant returns to scale, convexity and strong disposability on input and output. The standard textbook equations are not being repeated here. We use the energy content of inputs given in the last column of Table 1. For the purpose of normalisation we divided the sum of the energy consumed in MJ by output of banana in kg. The minimum representing the most efficient farm was normalised to 1 in order to obtain an efficiency score for each farm. We find mean Technical Efficiency to be 0.70, Allocative efficiency to be 0.88 and Energy Efficiency to be 0.62 indicating a possibility of reduction in inputs and consequent energy consumption by as much as 38%.

Conclusion

Results indicate that energy inefficiency in modern agribusiness can be a result of mismanagement of inputs and/or their misallocation. The method given above can be applied to measure enery efficiency in the public sector enterprises. More importantly, the technique has to be extended to cover the cases where the energy content of inputs in uncertain.

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Author's note

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