Chapter V

Research and Development

In the present chapter an attempt is made to examine the research and development initiatives of Tata Motors (India) Ltd. and delineate the salient features of Tata Motors’ technology development strategy.

The focus Tata Motors technology management strategy has throughout been on building in-house technological capabilities by assigning due priority on research and development efforts. This specific focus is borne out by the facts that not only the company’s Engineering Research Centre (ERC) could achieve major breakthroughs in a variety of areas\(^1\) but also a large number of Tata Motors’ products could be designed and developed indigenously.

In fact, as shown in the preceding chapter, the total number of product/process launched by Tata Motors’ which were developed by its in-house R&D went up significantly after 2000-01 (during the period 2000-01 to 2008-09). Of all new products launched during 1991-2000, 53.33 per cent were developed in-house; this proportion went up to 80.36% during the subsequent period (i.e., 2001-2009). Naturally, the proportion of new products launched by using imported technology came down from 43.33% in the first period (1991-2000) to less than 3.57% during the period 2000-01 to 2008-09. These figures are suggestive of the fact that Tata Motors has shifted its focus from
Technology import to In-house technology development in a phased manner.

5.1. R & D SET UP

The technology management strategy of Tata Motors had throughout been guided by the premise that no firm in the world would ever part with a state-of-the-art technology which was the source of its own competitive advantage; hence, developing in-house capabilities in technology would be the *sine-qua-non* for ensuring corporate survival and growth.²

The above realization has prompted Tata Motors to create over the years a large and comprehensive design and development set-up.

The Research Centre at Jamshedpur regularly upgrades components and aggregates. A well-equipped torture track enables rigorous and exhaustive testing of modifications before they are used as regular fitments.

The Engineering Research Centre (ERC) in Pune was set up in 1966 and is considered one of the finest in the country. It has been honored with two prestigious awards - 'The DSIR National Award for R&D Effort in Industry - 1999' and 'National Award for Successful Commercialization of Indigenous Technology by an Industrial Concern - 2000'.³

ERC (Engineering Research Center) is equipped with state-of-the art facilities in designing, manufacturing and testing. In its annual reports the company claims to have developed core competencies in designing automobiles such as light commercial vehicles (LCVs), medium commercial vehicles (MCVs), heavy commercial vehicles (HCVs) and
multi-utility passenger vehicles (MPVs) for Indian conditions. The centre could successfully develop an LCV which has been competing with international brands. Tata Motors has put in major design efforts for intermediate commercial vehicles and new passenger car model in the MPV category.

The Engineering Research Center employs a large number of engineers and scientists, and has been endowed with state-of-art R&D facilities. The aim of ERC is to introduce cost effective and environmentally sustainable technologies, ensuring that all of its vehicles meet the international norms on emission and safety. In fact ERC has proved to be breeding ground for the automobile technologists for the entire automobile industry in India. As a result of ERC's initial efforts, Tata Motors was selling the same HCV in African market at half the price than that of Mercedes. This experience of Tata Motors helped it in understanding the importance of indigenization and advantage of having a dedicated R&D facility equipped with state-of-art design and testing instruments. High degree of vertical integration helped initially in maintaining the quality of components.

The research & development facilities in ERC comprises of the following:

- Test Beds
- Chassis Dynamometer Emission Lab
- Electrodynamic Vibration Shaker Platform
- Instrumentation Laboratory
Test Beds

Tata Motors has 24 engine test beds for engine development. These are fully automated with computerised data acquisition and logging. They are used to test performance, endurance, and durability. They are also used in development of components and other engine aggregates. The dynamometers ranging from 200 Hp to 500 Hp are capable of looking after all the existing and future petrol, diesel, and CNG engines of Tata Motors. Three test beds are equipped with emission analysers. They are engaged in emission development for Euro norms. Six test beds are equipped with 'Intake Air Conditioning Systems' to feed combustion air at ref. temp, pressure and humidity to the engine.

The latest addition is a contemporary "High Dynamic Transient Dynamometer" (HDTD) installed in December 2000 which permits all 'chassis dynamometer' drive cycles to be run on it. It has an Emission System, Dynamometer and Software. The powerful software simulates the driver and all vehicle aggregates like gearbox and drive train, other than the engine.7

Chassis Dynamometer Emission Lab

The ERC has a specialised AVL Zollner Chassis Dynamometer with a 508mm-twin roller for checking the emission levels of chassis. It is certified by UTAC, TUV, INTA and ARAI. With a 125 kw generator, it can cater to the maximum vehicle speed of 210 km/h. Inertia simulation ranges from 567kg to 3000 kg. The Horiba 9000 emission system has separate CVS units for petrol and diesel.8
Electrodynamic Vibration Shaker Platform

It is used for testing engine components and assemblies against vibrations. It works with a rated force of 2000 kgf on X, Y and Z-axis. The maximum displacement is 40 mm and the maximum acceleration is 65g. It has a platform table size of 1000x1000 mm. The whole set-up has a PC based control and automation system.

Instrumentation Laboratory

The 'Instrumentation Laboratory' at ERC Engines is equipped with a range of instruments to assist engine development. These include data acquisition systems, air flow meters, blow-by meters, smoke meters, oil consumption meters, incometer & topometer, piston profile tester, FIP test rig, Swirl test rig, and many other support equipments to cater to routine engine development activities.

Specialized laboratory for research on emissions

A specialized laboratory has been set up to measure levels of emission of vehicles using petrol, diesel or CNG. This laboratory helps Tata Motors achieve fuel consumption efficiencies that would conform to international standards, under varying driving cycles. It stands testimony to Tata Motors commitment to help bring down levels of atmospheric pollution caused by vehicular exhaust.

Test Tracks

High-speed tracks are specialized tracks for testing endurance of cars and commercial vehicles. The Tata Motors torture tracks and high-speed tracks in Jamshedpur and Pune are the only one of their kind in
the country. The torture track has 4 segments. Each segment affords a different type and level of stress testing for the vehicle chassis and aggregates. The tracks subject the chassis to shock, twisting and bending loads. 1000 cycles on this torture track are equivalent to approximately one and a half lakh kms of running on regular roads. It thus provides a valid test of chassis and vehicle durability.\textsuperscript{10}

**Four Poster Servo-Hydraulic Test Facility**

Four-Poster Servo-Hydraulic Test Facility consists of four posts for mounting the vehicle. The vehicle is subjected to vertical motions equivalent to road undulations similar to actual runs on a test track. These tests conducted in a lab under controlled conditions are accurate and unaffected by external factors that could hamper testing activity.

**Crash Test Facility:**

Tata Motors ERC is the only high-tech facility in India to evaluate the degree of passenger safety in the event of any high-speed impact. Through a special crash test facility. Different types of accidents are simulated; the results analysed, and put to use in the development of a vehicle that satisfies stringent international safety norms.

Special high-speed cameras record test crashes at the rate of 1000 frames per second. An accident, for instance, at the speed of 50 kilometers per hour, lasts one eighth of a second. Thus, 125 frames recorded by these cameras are available for study with the completion of each individual test.
Anechoic Chamber

Anechoic chamber is a highly sophisticated noise and vibration laboratory, the nerve centre of which is a vast chamber lined with 88,000 cones projecting at various angles from the walls and ceiling. It is one of its kind in India and is developed completely with in-house facilities.

A number of cones, made of glass wool, are covered with fire retardant material and absorb sound generated within this chamber. There are rubber dampers, and a meter-thick wall of air surrounds the chamber itself. Designed to achieve 99.5% noise absorption, the chamber is used to test noise and vibration levels created by vehicles.11

Designing and Styling (CAD CENTRE)

The CAD centre is equipped with 53 state-of-the-art CAD stations and the latest software. The CAD centre is a vital organ of ERC's Cab Design Section.

CAD designing involves development of vehicle specifications, styling interiors and exteriors, reviewing the styling from the engineering and aesthetic points of view, virtual prototyping to check for design acceptability and feasibility of manufacture. Based on this information, several running prototypes are made and tested. It is only after all flaws, if any, are corrected using CAD systems, that vehicles are approved for mass production.12
Central Tool Room, Jamshedpur

The Central Tool Room at Tata Motors, Jamshedpur is one of the most modern tool room in India. Equipped with the latest CNC Machines, Tryout Presses and Inspection facilities, this tool room has the proven capability of developing tooling solutions for all applications.

Manning the Design Function of CEM is a team of skilled professionals, having a judicious blend of youth and experience. In our work practice we emphasize in-house training, mentoring and documentation of learning. Our knowledge base/facilities include:

- 15 years on the CAD platform.
- 16 Silicon Graphics workstations.
- Software's like Euclid 3.24, Ideas Ms7, Pro-Engineer 2000i, DELCAM, OPTRIS.

5.2. R & D INTENSITY

Tata Motors of late has been spending around nearly 5.75% of its annual revenues (year 2009) on R&D. This amount is much higher than the spending of other manufacturers in the Indian automobile industry; however it is comparable to what a firm of the same size (in terms of revenues) spends in Japan or US. It employs nearly 2000 scientists and technologists in its ERC which is more than the number of people employed by an equivalent firm in the developed countries.

However, since 2004-05, a sustained effort was noticeable in the company for attaining R & D intensity comparable to the firms in Japan or US.
Table 5.1 below shows the R & D intensity in some of the world’s leading automobile companies:

<table>
<thead>
<tr>
<th>Company/Year</th>
<th>R &amp; D Expenditure as % of Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota</td>
<td>3.9</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>4.3</td>
</tr>
<tr>
<td>Ford</td>
<td>4.5</td>
</tr>
<tr>
<td>Honda</td>
<td>5.2</td>
</tr>
<tr>
<td>GM</td>
<td>3.5</td>
</tr>
<tr>
<td>Nissan</td>
<td>4.2</td>
</tr>
<tr>
<td>Tata Motors</td>
<td>2.1</td>
</tr>
</tbody>
</table>

(-) indicates Not available.

Sources: Annual Reports of Toyota (various Years), Annual Reports of Volkswagen (various Years), Annual reports of Ford (various Years), Annual Reports of Honda (various Years), Annual Reports of GM (various Years), Annual Reports of Nissan Motors (various Years), Annual Reports of Tata Motors Ltd. (Various Years).

From the above table it is clear that Toyota’s R&D expenditure as a percentage of turnover is 3.1% in 2007-08. Thus in an average from 2004-05 to 2007-08 Toyota’s R&D expenditure as a percentage of turnover is 3.58%. Volkswagen’s R&D expenditure as a percentage of turnover is 5.5% in 2007-08. Thus in an average from 2004-05 to 2007-08 Volkswagen’s R&D expenditure as a percentage of turnover is 4.78 %. Ford’s R&D expenditure as a percentage of turnover is 4.3% in 2006-07. Thus in an average from 2004-05 to 2006-07 Ford’s R&D expenditure as a percentage of turnover is 4.43%. Similarly, Honda’s R&D expenditure as a percentage of turnover is 4.9% in 2007-08. Thus in an average from 2004-05 to 2007-08 Honda’s R&D expenditure as a percentage of
turnover is 5.0%. GM’s R&D expenditure as a percentage of turnover is 4.5% in 2006-07. Thus in an average from 2004-05 to 2006-07 GM’s R&D expenditure as a percentage of turnover is 3.73%. Nissan’s R&D expenditure as a percentage of turnover is 4.2% in 2007-08. Thus in an average from 2004-05 to 2007-08 Nissan’s R&D expenditure as a percentage of turnover is 4.25%. In case of Tata Motors R&D expenditure as a percentage of turnover is 2.88%.

The rate of growth in R & D expenditure and the R & D intensity in Tata Motors is shown in Table 5.II below:

<table>
<thead>
<tr>
<th>Year</th>
<th>R &amp; D Expenditure (Rs. Crore)</th>
<th>Y on Y growth (%) in R &amp; D Expenditure</th>
<th>Turnover (Rs. Crore)</th>
<th>R &amp; D Exp as % of Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-92</td>
<td>19.99</td>
<td>59.9</td>
<td>3021.36</td>
<td>0.66</td>
</tr>
<tr>
<td>1992-93</td>
<td>31.96</td>
<td>192.7</td>
<td>2875.86</td>
<td>1.11</td>
</tr>
<tr>
<td>1993-94</td>
<td>93.55</td>
<td>-19.5</td>
<td>3543.09</td>
<td>2.64</td>
</tr>
<tr>
<td>1994-95</td>
<td>75.30</td>
<td>47.0</td>
<td>5511.46</td>
<td>1.37</td>
</tr>
<tr>
<td>1995-96</td>
<td>110.68</td>
<td>49.3</td>
<td>7636.46</td>
<td>1.45</td>
</tr>
<tr>
<td>1996-97</td>
<td>165.27</td>
<td>-10.4</td>
<td>9768.32</td>
<td>1.69</td>
</tr>
<tr>
<td>1997-98</td>
<td>148.07</td>
<td>-29.9</td>
<td>7026.50</td>
<td>2.11</td>
</tr>
<tr>
<td>1998-99</td>
<td>103.75</td>
<td>8.7</td>
<td>6317.89</td>
<td>1.64</td>
</tr>
<tr>
<td>1999-00</td>
<td>112.80</td>
<td>-18.4</td>
<td>8624.77</td>
<td>1.31</td>
</tr>
<tr>
<td>2000-01</td>
<td>92.00</td>
<td>18.5</td>
<td>7906.29</td>
<td>1.16</td>
</tr>
<tr>
<td>2001-02</td>
<td>109.00</td>
<td>31.2</td>
<td>8636.71</td>
<td>1.26</td>
</tr>
<tr>
<td>2002-03</td>
<td>143.00</td>
<td>6.2</td>
<td>10604.04</td>
<td>1.35</td>
</tr>
<tr>
<td>2003-04</td>
<td>151.88</td>
<td>140.2</td>
<td>15208.74</td>
<td>1.00</td>
</tr>
<tr>
<td>2004-05</td>
<td>364.78</td>
<td>30.5</td>
<td>20217.42</td>
<td>1.80</td>
</tr>
<tr>
<td>2005-06</td>
<td>476.12</td>
<td>67.4</td>
<td>23439.41</td>
<td>2.03</td>
</tr>
<tr>
<td>2006-07</td>
<td>796.86</td>
<td>71.3</td>
<td>30999.43</td>
<td>2.57</td>
</tr>
<tr>
<td>2007-08</td>
<td>1365.00</td>
<td>20.5</td>
<td>32521.83</td>
<td>4.20</td>
</tr>
<tr>
<td>2008-09</td>
<td>1644.56</td>
<td>59.9</td>
<td>28599.27</td>
<td>5.75</td>
</tr>
</tbody>
</table>

Source: Tata Motors annual reports (various years)
R&D expenditure of Tata Motors was increasing from the beginning and was Rs 93.55 crore in 1993-1994. Then it decreased in the year 1994-1995 with Rs 75.30 crore. From 2000-2001 the R&D expenditure was increasing steadily and raised to highest value in 2008-2009.

In fact, throughout the period under consideration, Tata Motors had been investing in a planned manner in R&D. Tata Motors R&D expenditure as a percentage of turnover was only 0.66% in 1991-1992. The same increased to 1.80 per cent in 2004-05. However, noticeable increase in R & D intensity came thereafter and R&D expenditure as a percentage of turn over increased to 5.75% in the year 2008-2009.

The focus on development of in-house technological capabilities would be clear if one compares the R & D expenditure with the annual out-go on account of foreign technical collaboration. Table 5.III may be considered in this connection:
Table 5.III: Royalty Paid* by Tata Motors

<table>
<thead>
<tr>
<th>Year</th>
<th>Royalty Paid (Rs. Crore)</th>
<th>Total Operating Cost (Rs. Crore)</th>
<th>Royalty as % of Operating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-92</td>
<td>0.89</td>
<td>2840.38</td>
<td>0.03</td>
</tr>
<tr>
<td>1992-93</td>
<td>1.83</td>
<td>2860.99</td>
<td>0.06</td>
</tr>
<tr>
<td>1993-94</td>
<td>1.49</td>
<td>3428.50</td>
<td>0.04</td>
</tr>
<tr>
<td>1994-95</td>
<td>2.75</td>
<td>5073.19</td>
<td>0.05</td>
</tr>
<tr>
<td>1995-96</td>
<td>11.31</td>
<td>7881.08</td>
<td>0.14</td>
</tr>
<tr>
<td>1996-97</td>
<td>56.42</td>
<td>10128.43</td>
<td>0.56</td>
</tr>
<tr>
<td>1997-98</td>
<td>8.33</td>
<td>6855.67</td>
<td>0.12</td>
</tr>
<tr>
<td>1998-99</td>
<td>4.45</td>
<td>6455.88</td>
<td>0.07</td>
</tr>
<tr>
<td>1999-00</td>
<td>9.73</td>
<td>8401.95</td>
<td>0.12</td>
</tr>
<tr>
<td>2000-01</td>
<td>9.16</td>
<td>7778.67</td>
<td>0.12</td>
</tr>
<tr>
<td>2001-02</td>
<td>16.68</td>
<td>6905.83</td>
<td>0.24</td>
</tr>
<tr>
<td>2002-03</td>
<td>29.9</td>
<td>8110.27</td>
<td>0.37</td>
</tr>
<tr>
<td>2003-04</td>
<td>16.77</td>
<td>11486.31</td>
<td>0.15</td>
</tr>
<tr>
<td>2004-05</td>
<td>76.89</td>
<td>15530.47</td>
<td>0.50</td>
</tr>
<tr>
<td>2005-06</td>
<td>91.56</td>
<td>18386.66</td>
<td>0.50</td>
</tr>
<tr>
<td>2006-07</td>
<td>188.88</td>
<td>24798.57</td>
<td>0.76</td>
</tr>
<tr>
<td>2007-08</td>
<td>172.21</td>
<td>26552.05</td>
<td>0.65</td>
</tr>
<tr>
<td>2008-09</td>
<td>160.60</td>
<td>24824.37</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Royalty paid indicates the recurring annual expenditure incurred by the company for foreign technical collaboration.

Source: Tata Motors annual reports (various years).

From the above it is clear that the Royalty paid by Tata Motors annually was too small compared to the company’s annual R & D Expenditure (as shown in Table 5.II earlier) and the former was well below even 1 per cent of the company’s operating cost.

5.3. PRODUCT/PROCESS DEVELOPMENT INITIATIVES

Tata Motors which has created significant milestones in its long and accelerated journey from truck to Nano has persistently focused on in-
house R & D efforts. The company widened over the years the scope of its research and development activity from in-house product and technology development to managing research and development process across various internal and external agencies, including its research and development centers in Korea, Spain and United Kingdom. The Company’s research and development initiatives include developing vehicles running on alternative fuels, including CNG, LPG and bio-diesel and pursuing alternative fuel options such as ethanol blending and development of vehicles fuelled by hydrogen.


Research provides the much-needed inspiration for the birth of new ideas, which in turn breathes new life into products. World-class automotive research and development are key factors that contribute to the leadership of the Company. The R&D unit as pointed out earlier is very vital and is not standalone rather it is very much integrated within the manufacturing. It is continuously working for developing new technology, new products and methods best in the industry. The R&D serves as the nerve center for the Tata Motors. Presently there are three
R&D units of Tata Motors in India Jamshedpur, Pune and Lucknow. And others are in Spain, South Korea and UK. Due to the R&D effort the Indica came out, Tata Ace (the best small Pickup in its segment), Nano, and also the World Truck. And not only is that but the modifications on the existing product also through the effort of in-house R&D.

At Tata Motors, investment in R&D is seen as a continuous process, and returns are calculated on long term basis and not on annual basis. "When technology acquisition started in 1983, Tata Motors increased its annual outlay on R&D. We felt that the need of the hour was to develop our technology base, and we decided to enhance our product and process technologies. We are in a comfortable position as far as LCVs and HCVs are concerned, and our MPVs are making in-roads in Indian and foreign markets. These are the results of our last 10 years of efforts and we have concrete plans for the next 10 years," says the CTO.

The CTO disagrees to the argument that, the firms with higher volumes can only afford to do R&D. "If the firms in developed countries cut cost exploiting economies of scale, we in India, compensate it with low overheads and therefore, the resources can be spared to do R&D. There should be a commitment and inclination to do R&D, resources can always be mobilized," feels the CTO.

"It is a very modest R&D effort which Tata Motors is putting up in comparison to developed countries, but by Indian standards it is just fabulous," observes the CTO. Tata Motors knows that in order to sustain its current position in the Indian market, its current investments
will have to be further enhanced. On the whole, Tata Motors has an
enviable track record in technology management process.

The company widened the scope of its research and development
activity from in-house product and technology development to
managing research and development process across various internal
and external agencies, including its research and development centers
in Korea, Spain and United Kingdom, as well as at various aggregate
parts suppliers and outsourcing partners. The Company's research and
development initiatives include developing vehicles running on
alternative fuels, including CNG, LPG and bio-diesel and pursuing
alternative fuel options such as ethanol blending and development of
vehicles fuelled by hydrogen. The Company is also pursuing various
initiatives in engine management systems, vehicle network
architecture, vehicle tracking and telematics.

Some of the major breakthrough achievements of Tata Motors in the
field of product development are discussed below:

First passenger car

Tata Motors rolled out its first commercial vehicle in 1954. After the
launch, the company studied various drawbacks in the launched
vehicle and introduced DI engines to make its trucks more efficient. In
1986, the company launched the first indigenous commercial vehicle,
Tata 407. The company received good response from the commercial
sector and so decided to enter the passenger cars segment.

After great research and studies, the company finally rolled out the first
indigenous passenger car, Tata Sierra, in 1991. Initially the car was
propelled by a naturally aspired engine but later on a turbocharged version was introduced. Though the car is no more in production, it was believed to be one of the most durable cars in the Indian car industry.

**Tata Safari**

A couple of years after the launch of Tata Sierra, Tata Motors designed various new cars on different platforms. First it introduced a multi-utility vehicle, christened as Tata Sumo in 1994. During that time, other car manufacturers had also rolled out their car models on Indian roads. To have a competitive edge, Tata decided to come up with an effective and better version of Sumo and so a new Tata Sumo deluxe was launched in 1996.

Further to that, the company also introduced its first sports utility vehicle in the year 1998, codenamed Tata Safari. This newly launched Safari was not only the first SUV by Tata but also the first one to be designed and produced in the country. With further advancements, the car was extensively modified in 2005 with addition of a new DICOR engine coupled with modified car interiors and exteriors.

**Tata Indica**

Tata Motors was very much into the production of passenger cars and therefore the desire for manufacturing innovative and competitive car concepts kept on increasing. In response to its own desires, the company launched its fully indigenous car, Tata Indica, in 1998. The immediate year after the launch of Indica showed full swing commercial production of this new car. As and when the requirements
and demands of the customers kept on swinging, Tata also kept on bringing better versions and generations of Tata Indica.

In the year 2000, the company introduced a new version of Indica that was in compliance to the Bharat Stage II emission norms. This Indica 2000 was first launched with a diesel engine followed by a multi-point fuel injection petrol engine in the same year. Car owners had repeated complaints with the horsepower and gas mileage. In response to the prompted complaints by the customers, the company re-engineered the engine technology and introduced second generation, Indica V2, in 2001. In the later part of the year, CNG Indica was also introduced, making the car a big hit in the Indian market. Moving along with advancement and technology, Tata introduced many other versions of Tata Indica. Shaking hands with innovation, the third generation Indica, known as Tata Indica Vista or Tata Indica V3, is also launched in the year 2008.

**Tata Indigo**

After the successful journey of Tata Indica, a compact hatchback, the company aimed at shifting its production from hatchback to sedan. In the year 2002, Tata Motors unveiled Tata’s sedan, Tata Indigo, at Auto Expo 2002. The car was a big hit as entry mid-sizers with innovative features and improved engine technology.

As and when the days passed, advanced and innovative version came into picture. 2004 witnessed the launch of Tata Indigo Marina, in 2005 luxury variant Indigo SX series was introduced, and in 2006 the company unveils new long wheel base premium Indigo. In the later
part of 2006, Tata introduces a completely new range of Tata Indigo. In 2007, common rail diesel engine was introduced to Indigo sedan and eventually in 2008, a compact Indigo, popularly known as Tata Indigo CS, made its debut in the Indian car industry.

Nano

Of late, Tata Motors has entered a completely new segment of passenger car. The company’s vision is to design and produce the world’s cheapest car for a common man. This vision has translated itself into the small car: Nano. Arrival of this car is likely to revolutionize the Indian market and deeply affect the global car industry.18

5.4. SUMMING UP THE CHAPTER

Clearly, the technology management strategy of Tata Motors had throughout been guided by the premise that no firm in the world would ever part with a state-of-the-art technology which was the source of its own competitive advantage; hence, developing in-house capabilities in technology would be the *sine-qua-non* for ensuring corporate survival and growth. At least three important aspects of Tata Motors’ technology management strategy could be identified:

1. Focus on building in-house technological capabilities,

2. Advancing steadily, particularly after 2000-01, towards attaining globally comparable levels of R & D intensity,

3. Planned sequencing of phases for developing technological competence.
Within Tata Motors' strategy of building technological competence, we could discern three clear phases:

In the first phase, Tata Motors focus was on building the necessary competence so that the company can effectively adapt and absorb the technologies that were being acquired from foreign auto-manufacturers.

In the second phase, Tata Motors started utilizing its capabilities for unbundling the technology packs and then relying primarily on in-house R & D for developing separately each constituent of the technology-pack in question. In this phase, while it was still necessary to depend on foreign sources for acquiring the technology pertaining to some constituents of the technology pack in question, Tata Motors used to acquire this technology directly from the machine tool manufacturers. That means, in this phase there was no longer the need to look for any foreign auto-manufacturer for outright purchase of the entire technology package.

In the third phase, which started relatively recently, Tata Motors has been striving to place itself along the technological frontier by focusing on cutting edge technology and 'first' innovations.

While the evolution of Tata Motors’ technology management strategy, as delineated above, can be traced to a great extent to its corporate vision and forward looking management, the planned sequencing of the three phases is surely indicative of the proactive response of Tata Motors' management to the challenges and opportunities unleashed by the forces of globalization during the period following 1991. It is
worthwhile to note that during this period Tata Motors decided to
globalize its operation and hence was increasingly under pressure to
gain competitive edge in the global market by focusing on in-house
technological competence.
NOTES

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