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Profitability Study of Indian Pharmaceutical Industry: A Co Integration Approach

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Profitability (ROA) study of the Indian pharmaceutical industry has been studied under dynamic conditions to avoid endogeneity issues. Vector Error Correction Mode (VECM) results suggest short-run and long-run dependency of profitability on working capital intensity, research & development intensity, and physical capital intensity. Physical capital intensity exhibited a negative impact on ROA. Auto Regressive Distributed Lag (ARDL) results suggest short-run and long-run positive dependency on research & development intensity, working capital intensity, and leverage on profitability. Granger causality with two lags from fixed assets invested on net profits along with a strong positive correction suggests a longer payback period. This sector will require continuously high investments in physical capital intensity, operating capital, and research & development. Financing through debt can be undertaken with profitability but with prudence.

Keywords: Export intensity, Physical capital intensity, Leverage, Research and development intensity, Working capital management

Introduction

The Indian Pharmaceutical Industry (IPI) has been a significant player in the global market. Indian-based pharmaceutical firms have gained considerable market share worldwide in the twenty-first century. It ranks third worldwide and has a well-built network of 10500 manufacturing units and three thousand pharmaceutical companies. It is the fastest-growing industrial sector of India; According to the [1] report, India is the world's largest producer of generic drugs and contributes 20% of the global exports of generic drugs. Indian pharmaceutical companies export generic drugs and vaccines to over 200 countries worldwide, including highly regulated countries such as the United States, Western Europe, Australia, and Japan.[2]

Global pharmaceutical markets are going through considerable disruptions, growth will slow in mature economies, and emerging economies will become more critical over the next decade. The Indian pharmaceuticals market, along with China, Brazil, and Russia, will generate growth in these markets.[3]

Indian Pharmaceutical Industry

IPI has been the focus of several studies due to its competitiveness and later India's adoption of the product patent regime in 2005. The focus on generics and bio-similar has ensured that firms have developed competitiveness primarily based on pricing. To ensure competitiveness, firms promote branded generics in the domestic market.[2] Research and Development (R&D) investment has been increased to maintain competitiveness in the changing environment. For quite some time, India has been the second largest location(s) of USFDA-approved manufacturing units.

The profitability of an industrial sector ensures its existence. Many factors drive profitability in this industry than in other knowledge-intensive industries. It is unusual for a few specific reasons – the intensity of R&D with significant uncertainties, high ethical and regulatory standards, and other constraints of the manufacturing industry.[4] The firm's performance is mainly measured by the Return on Equity (ROE) or Return on Assets (ROA). ROA or in other words Net Profit/Total Assets is considered a better measure because Total Assets (TA) includes debt incurred by a firm (as opposed to ROE) and reflects the firm's ability to repay debt. Furthermore, as a manufacturing industry, the pharmaceutical industry is capital-intensive and requires a mix of debt and equity to function.[5]

In a study of IPI from 2000 to 2013, accretion to fixed assets, Export Intensity (EXI), patenting activity, and operating expenses (scaled to TA) were reported to have a positive effect on net profit margin. However, Research and Development Intensity (RDI)

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exhibited negative impact on profitability.[6] This period encompassed Financial Years (FYs) when R&D activities went down and also the Great Financial Crisis (GFC) occurred. However, extant works have proposed alternative outcomes concerning R&D expenditure. During the mailbox patent period, more prominent and established firms could improve profitability through investments in R&D. Better asset utilization resulted in increased sales and liquidity management.[7] A decadal study conducted after the GFC highlighted the role of asset management (both fixed and current assets) in defining IPI profitability.[8] If a more significant time is encompassed, then listed pharmaceutical firms have been observed to reflect a greater magnitude of the impact of R&D and asset utilization on profitability measures.[9]

Literature Review

A longitudinal study (1992–2004) of the impact ownership structure of South Korean pharmaceutical firms on output efficiency revealed a positive impact of Working Capital Management (WCM) and EXI mediated through RDI. In the Asian context, concentrated ownership indicates a short-term commitment. The same is reinforced by negative scale efficiency. The fixed assets' negative coefficient significantly indicated a lowered ROA.[10] A Fifteen-year period study (1997–2014) on particular IPI showed no correlation between WCM and profitability.[11] EXI positively and significantly influenced ROA among the large firms in IPI. A 10% rise in EXI leading to a 0.70% increase in ROA, implied that firms focused on exports outperform those primarily focused on local markets.[12]

During the 2001–2004 economic slump, Swiss pharmaceutical manufacturers managed WC by consolidation, keeping a lean inventory, and lowering average Account Receivable (AR). Process chemistry advancements increased yields, relieving pressure on Inventory Turnover Period (INV).[13] Greek pharmaceutical industry exhibited change in correlation between AR and profitability in the pre- and post-crisis period (2005–09 to 2010–14). In particular negative impact of an increase in AR on profitability post the crisis was almost ten times compared to the pre-crisis period.[14]

To conserve cash holdings post GFC listed manufacturing firm of BSE reduced their scale of operation by reducing their Working Capital (WC), R&D, and debt.[15]

A study of examined Belgian non-financial companies from 1992 to 1996, and the results revealed that a reduction in AR and INV enhanced ROA. Controlling for the fixed assets, a ten-day Cash Conversion Cycle (CCC) shortening increased the operating income by 0.16%.[16] Indian manufacturing firms which between 2004 to 2013, invested heavily in fixed asset had to resort to aggressive WCM to avoid liquidity concerns. There firms invested less in CA.[17]

Between 2003 and 2013, growth in Net Fixed Assets (NFA) of medium-sized pharmaceutical firms led to a decrease in RDI.[18] This trade-off was on account of competition from China in APIs. The role of NFA in IPI has so far been confounding. A selective study of firms in IPI for the period 2002 to 2006 was inconclusive on the impact of physical capital intensity (NFAT) and assets turnover ratio (Sales/NFA).[19]

A study of nine Indonesian pharmaceutical firms revealed that NFA and TA exhibited diametrically opposite contributions (roles) to ROA in conjunction with sales. These firms were able to get the benefits of scale (NFA); however, inefficient current assets management led to negative total asset turnover ratio (sales/TA).[20] Net Fixed Assets Turnover ratio (NFAT) had a significant and detrimental impact on the profitability of the pharmaceutical sector during the Greek economic crisis. On the other hand, R&D had a favourable influence.[21] The exit of small firms from the IPI did not change R&D behaviour. Only in the cases of medium-sized firms (Rs. 1000–9999 million in annual sales) did lagged sales increase the current year's R&D expenditure.[22]

A longitudinal study of 20 years from the time of the accession to WTO (1995–2015) of large firms in IPI showed positive feedback on R&D to profitability.[23] The possibility of an endogenous relationship between WC and R&D was reported for Israeli firms from 2008–2016. A Change in Net Working Capital Requirement (NWCR) induced a change in RDI in the same direction. One Standard Deviation (SD) shock of NWCR was observed to produce a change in RDI by 175.60%.[24]

A longitudinal study including the structural break (sales) year (2012) revealed the detrimental repercussions of increased sales on profitability. Furthermore, the influence of R&D was found to play a contradictory function in profitability. R&D in process development was shown to have a beneficial impact, whereas product development had a negative impact.[12]

A study of 32 Pakistani firms for the period 2006 to 2016, showed that leverage could have both negative and positive effects on firm performance (return on equity). A high level of debt reduced ROE by

approximately 2%, *ceteris paribus*.[25] Fixed effect regression of big Indian pharmaceutical enterprises post-WTO entry revealed a return on R&D of around 50% on profitability. Physical capital investments showed declining returns in IPI.[26]

The GFC negatively impacted the profitability of IPI mediated through leverage until 2017.[(27)] Large enterprises in IPI carefully controlled their indebtedness, resulting in LEV's beneficial influence on ROA.[12]

Knowledge Gap

Extant work on IPI relates more to the post product patent period, with mixed impact of R&D and asset turnover contributions' to profitability. Studies on impact of leverage, and current assets including liquidity management have also shown divergent results. The effect of fixed assets, being a manufacturing industry, has also not been clearly delineated. Issues of endogeneity persist in these studies. Dynamic equilibrium takes into account issues of endogeneity and simultaneously provides short-run & long-run estimation models. This study will attempt to fill this gap by taking dynamic estimation of parameters impacting the profitability of IPI.

Data and Methodology

Profitability is a way of assessing the competitiveness and survivability of the firm and the industry. Maintenance and growth in profitability indicate dynamism. To capture long-term and short-term movements, the industry's 31–year period, performance and operational parameters have been taken. Annual financial data of IPI has been taken from CMIE Prowess for the period 1990–2020. Selected variables are shown in Table 1.

To avoid time series fluctuation, variables have been scaled by assets except for export and R&D, which have been scaled by sales. This study is divided into two econometric analyses; the Error Correction Mechanism (ECM) has been studied under the Vector Error Correction Model (VECM) and Auto Regressive Distributed Lag (ARDL) techniques.[28] Problems of endogeneity are removed in these dynamic modelling techniques. To establish causation and direction, Granger Causation (GC) will be used between two stationary variables.[29] Most financial data in time series are at mixed levels- stationary I (0) and non – stationary I (1). Eviews 10 will be used for analyses.

Only successful and relevant iteration will be mentioned and discussed. Trend of variables is seen in Fig. 1 on a yearly basis.

Table 1 — Variables Selected

Variable	Acronym	Formula	Reason
Return on Assets	ROA	$\frac{Net\ Profit}{Total\ Assets}$	ROA is a measure of industry profitability.
Net Working Capital Requirement	NWCR	$\frac{(CA - CA\ )}{Total\ Assets}$	It is a measure of working capital management.
Leverage	LEV	$\frac{(Debt\ )}{Total\ Assets}$	It is a measure of solvency.
Net fixed assets Turnover ratio	NFAT	$\frac{(Net\ fixed\ Assets\ )}{Total\ Assets}$	It is a measure of physical capital intensity (property, plants, and equipment).
Export Intensity	EXI	$\frac{(Export\ )}{Total\ Assets}$	It is the measure of export competitiveness.
Research and Development Intensity	RDI	$\frac{(R\&D\ )}{Total\ Assets}$	It is the measure of R&D commitment.

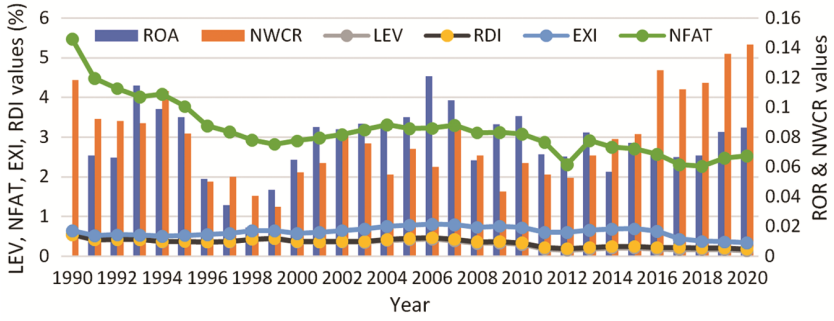

Fig. 1 — Plot of ROA, NWCR, LEV NFAT EXI and R&DI from sample data
Source: Collected and organized by the authors

Table 2 — Structure Break

Variables	First difference		Variables	First difference	
	t-Statistic (Break Year)	t-Statistic (Break Year)		t-Statistic (Break Year)	t-Statistic (Break Year)
NWCR	−3.662 (2015)	−7.153*** (2009)	Current Assets	−5.688*** (2011)	−7.771*** (2010)
			Current liabilities	−6.505*** (2010)	−4.706** (2010)
			Total Assets	−3.370 (2011)	−4.932** (2008)
ROA	−4.295* (1999)	−6.151*** (2009)	Net Profit	−1.383 (2013)	−5.781*** (1999)
NFAT	−2.203 (2004)	−9.067*** (2016)	Net Fixed Assets	−6.368*** (2012)	−8.160*** (2008)
LEV	−4.627** (2009)	−5.636*** (1998)	Debt	−1.940 (2011)	−4.620** (2003)
EXI	−3.352 (1995)	−10.195*** (2012)	Export	−5.028*** (2012)	−3.633 (2009)
			Sales	−2.229 (2012)	−5.534** (2010)
RDI	−3.484 (2001)	−5.302*** (2017)	Research & Development	−5.502*** (2014)	−4.209** (2009)

Source: Authors' compilation
Note: *** denotes significance at the 1% level.
** denotes significance at the 5%t level.
* denotes significance at the 10% level.

Results and Discussion

Structural Break in the Indian Pharmaceutical Industry

Since the study period encompasses significant changes in Indian and world economy, the variables and their constituents were subjected to Structural Break Unit Root tests. A structural break is a sharp increase or decrease in an economic time series induced, among other things, by a change in regime, policy direction, or external shocks. Structural breaks can occur in either the intercept or the trend, or both.[30] Structural break in the variables (series) and their constituents are displayed in Table 2 .

NWCR shows structural break in 2009, because of GFC. The ensuing liquidity crisis made WCM difficult. The components of NWCR, also show structural break on account of carryover of GFC effect on Current Liability (CL) in 2010 and Current Assets (CA) in 2011 (on account of firms accumulating higher inventory) respectively.

ROA showed structural breaks in 1999 and 2009. In 1999, the break was on account of significant rise of NP in firms and higher investments in fixed assets to expand and undertake technological up gradations. Second structural break in 2009 was due to GFC.

NFAT showed structural break in 2016 because of disproportionate increase in NFA. In 2012, some firms (e.g., Abbott India Ltd.) increase their fixed assets. NFA started growing significantly from 2011 onwards and by 2020 had achieved a CAGR of 13.1%. Bigger pharmaceutical firms showed a huge accretion in NFA on account of asset creation and acquisitions.

LEV showed structural break in 2009, however, long term debt (Debt) showed structural break in 2003. In this period, pharmaceutical companies (Morepen, Aurobindo, Orchid and Hindustan Antibiotic Ltd) incurred debt to fund mergers & acquisitions.

EXI showed structural break in 2012 because for the first-time, export intensity in this sector touched 4% (within the study period). In 2012, export by companies (Dr. Reddy's Laboratories Ltd., Cipla Ltd., Aurobindo Pharma Ltd., Lupin Ltd., Mylan Laboratories Ltd., Divi's Laboratories Ltd., Cadila Healthcare Ltd., Orchid Pharma Ltd., and Sun Pharmaceutical Ind.) increased significantly due to low production cost as compared to MNC pharmaceutical companies in the US (*The Economic Times*).

RDI showed structural break in 2017. RDI plateaued from 2017 onwards. However, R&D expenditure also showed a structural break in 2014, due to the significant rise of R&D by the industry.

Sales showed a structural break in 2010. In the period 1990–2010, sales grew at a CAGR of 9.96%; between 2010 and 2020, sales grew at a CAGR of 8.32%.

Correlation of ROA (Table 3) with RDI and LEV is moderate. Remaining IVs exhibit mild correlation with ROA. The Variables (series) were subjected to Augmented Dickey-Fuller unit root test. All the variables (series) except LEV were observed to be I (1).

Part 1: - Vector Error Correction Modal (VECM)

Variables taken for VECM analysis are ROA, NWCR, RDI, and NFAT. All the variables in this analysis are I (1) as per the requirement of VECM. Max-Eigen value (co-integration) indicates three co-integration equations with linear deterministic trend (restricted) in Johansen co-integration test (Table 4).

Lag selection was done by Vector Auto Regression (VAR) and VEC Lag Exclusion Wald Tests and 3 lags were selected. Lag order of 3 and upwards in VECM is in line with extant literature. It's large enough to avoid possible residual problem(s).[30]

Co-integration substituted coefficient equation is as follows:

$$D(ROA) = -0.4748*(ROA(-1) - 0.1302*NFAT(-1) + 1.6203*NWCR(-1) - 0.2140*EXI(-1) + 0.2074) - 0.4420*D(ROA(-1)) - 0.6609*D(ROA(-2)) + 0.02053*D(ROA(-3)) - 0.0033*D(NFAT(-1)) + 0.0245*D(NFAT(-2)) + 0.0304*D(NFAT(-3)) + 0.9390*D(NWCR(-1)) + 0.5863*D(NWCR(-2)) + 0.4783*D(NWCR(-3)) - 0.2802*D(EXI(-1)) - 0.1765*D(EXI(-2)) - 0.3520*D(EXI(-3)) + 0.0074 \quad \ldots(1)$$

There is an error correction of 47.48% (Eq. 1). The error correction is highly significant with t – statistic value of −4.3642. Approximately 48% disequilibrium in ROA of pharmaceutical industry is corrected each year. In two years almost 100% correction (reversion to equilibrium) happens. The model passed all residual tests-nil autocorrelation, normal distribution and absence of heteroscedasticity.

ROA is highly elastic to change in NWCR. The 10% change in NWCR causes a change of 16.2% in ROA in the same direction (*ceteris paribus*) similar to us reported as study firm in European Union.[31] This is supported by a strong correlation (r = 0.97) between NP and WC. This indicates efficient management of WC i.e., industry covers short-term liability through short-term assets.[32] A 10% change in EXI produces a change of 2.140% in ROA in the same direction. A 10% change in NFAT produces a change of 1.302% in ROA on average, in opposite direction (Table 5).

The GC from RDI to NWCR implies that a rise in R&D spending leads to a larger consumption of WC the following year, implying a year-lag migration from the laboratory to the commercial stage. The link between EXI and RDI is due to international market dynamics forcing the sector to invest in quality and cost competitiveness. One year lag was noted for GC from NFAT to NWCR. After one-year, fixed assets are likely to demand significant operational capital. GC from NWCR to EXI, on the other hand, denotes growing WC allocation, which leads to greater exports, most likely as a result of increased credit sales, which also include exports.[33]

A strong correlation (r = 0.98) is observed between NFA and NP. Also, there is a strong GC (at 2 lags) from NFA to NP (Table 6). Accretion to fixed assets results in significant rise in NP thereby impacting ROA. As ROA returns to equilibrium in just over two

Table 3 — Correlation

Variables	ROA	NWCR	NFA	LEV	EXI	RDI
ROA	1					
NWCR	0.208	1				
NFAT	−0.248	0.162	1			
LEV	−0.473	−0.371	0.745	1		
EXI	0.373	−0.353	−0.620	−0.415	1	
RDI	0.470	0.259	−0.760	−0.821	0.635	1

Table 4 — Co- Integration

Rank	Trace		Maximum Eigen value	
	Eigen–value	Statistic	Eigen–value	Statistic
None	0.731***	82.587	0.731***	35.50
At most 1	0.677***	47.078	0.677***	30.51
At most 2	0.449**	16.561	0.449**	16.09
At most 3	0.016	0.4624	0.016	0.462

Source: Authors' compilation

Note: *** denotes significance at the 1% level.

** denotes significance at the 5%t level.

* denotes significance at the 10% level.

Table 5 — OLS coefficients (Long–Run)
Generate by VECM model

Variables	Coefficients	Standard Error	T- statistic	Prob.**
NWCR	1.620	(0.550)	2.942	(0.000)
EXI	0.214	(0.085)	2.514	(0.000)
NFAT	−0.130	(0.027)	4.780	(0.000)

years, the shock is unlikely to be of higher magnitude.[34]

A positive shock of one SD change in EXI only (one SD of EXI = 0.11758 or change in EXI by 11.758%) causes a decrease of 0.56% in ROA in second year. By the fifth year the reduction in profitability by 2.03% and the accumulated decrease by tenth year is 2.46%. Any increase in EXI results in a minuscule but significant decrease in ROA. A positive shock of one SD change in NWCR only (one SD of NWCR = 0.2710 or change in NWCR by 27.10%) causes an increase of 0.36% in ROA in second year. By the second year, the increase in profitability is by 2.60% and maintaining the same till tenth year. A positive shock of one SD change in NFAT only (one SD of NFAT = 0.8566 or change in NWCR by 85.66%) causes an increase of 0.95% in ROA in first year. By the second year the increase in profitability by 4.50% and the accumulated increase by tenth year is 9.63%. This suggests that the impact of increase in physical capital intensity on ROA is spread over longer period of time (Table 7).

The outcomes of the forecast error variance decomposition are displayed in Table 8, which shows how much of the unanticipated changes of the variables are explained by different shocks. Variance decompositions depict the percentage of forecast variance (i.e., the percentage of variance in the forecast) in one variable of the VAR that is explained by all variables within the VAR's innovations. A change to a single variable within a VAR affects only variables ordered after that variable.

If three lags are taken as short run, then, Forecast Error Variance (FEV) in ROA is caused approximately 8.85% by shock or innovation in EXI, 6.81% by NWCR and 35.58% by NFAT. FEV in ROA subsequently increases by tenth year due to shock or innovation (shock = SD) in EXI, NWCR and NFAT to approximately 6.88%, 7.81% and 43.87% respectively.

The difference in the variance decompositions caused by the individual IVs can be attributed to the magnitude of SD of each IV. It can be assigned to the differences in SD of EXI, NWCR and NFAT (0.11758, 0.2710 and 0.85668 respectively). These differences arose most likely due to structural break occurring in the above variables in different time periods.

Part: - 2 Auto-Regressive Distributed Lag (ARDL) Bounds Tests Approach to Co-integration

ARDL technique for co- integration was proposed by Pesaran[35,36] it can be used when variables are I (0), and I (1), and mutually co-integrated. There are two steps to the ARDL co-integration technique. The first stage is to determine whether the variables in the model have a long-term relationship i.e., if co-integration exists. The second stage is to estimate the long-run and short-run coefficients using ARDL and ECMs.

For this study, bounds test results indicated co-integration when ROA is the dependent variable (series).

At 1% significance level, the estimated F-statistic exceeds the lower bound critical value. This means that the null hypothesis of no co-integration is firmly rejected, and that ROA and its

Table 6 — Granger Causality

Null Hypothesis:	Obs	F-Statistic	Prob.
Lags: 1			
RDI → NWCR	30	5.94	0.024
EXI → RDI	30	9.29	0.005
NWCR → EXI	30	10.41	0.003
NFAT → NWCR	30	4.99	0.033
Lags: 2			
NFA → NP	29	4.00	0.031

Source: Authors' compilation

Table 7 — Accumulated Impulse Response of ROA

Period	ROA	NFAT	NWCR	EXI
1	0.0129	0.0000	0.0000	0.0000
2	0.0233	0.0095	0.0036	−0.0056
3	0.0310	0.0219	0.0094	−0.0110
4	0.0429	0.0295	0.0174	−0.0193
5	0.0547	0.0335	0.0260	−0.0203
6	0.0615	0.0450	0.0282	−0.0168
7	0.0730	0.0575	0.0273	−0.0166
8	0.0834	0.0703	0.0248	−0.0217
9	0.0902	0.0828	0.0246	−0.0239
10	0.1001	0.0963	0.0250	−0.0246

Source: Authors' compilation

Table 8 — Variance Decomposition

Period	S.E.	ROA	NFAT	NWCR	EXI
1	0.012	100	0.00	0.00	0.00
2	0.020	66.90	22.15	3.30	7.63
3	0.026	48.74	35.58	6.81	8.85
4	0.031	46.79	29.65	10.85	12.69
5	0.035	49.24	25.49	14.82	10.43
6	0.038	45.84	31.09	13.16	9.89
7	0.041	45.83	34.91	11.01	8.23
8	0.045	44.31	37.75	9.67	8.25
9	0.047	42.22	41.28	8.77	7.71
10	0.050	41.43	43.87	7.81	6.88

Source: Authors' compilation

determinants have a long-term relationship (Table 9). To undertake Error Correction Model (ECM) estimation first, the long-run model needs to be specified with appropriate lag. Lag length Lag suggested by VEC lag Exclusion Wald test and 1 lag was selected.

The ARDL (1, 0, 0, 0) model in Table 10 is as per Eq. (2), with co-integrating equation as Eq. (3)

$$ROA = 0.4016*ROA(-1) + 0.5692*RDI + 0.2567*NWCR + 0.1269*LEV - 0.0280 \quad \ldots (2)$$

Table 9 — Bound Test

K	N	F-statistic	Upper (5%)	Lower (1%)	Decision
3	31	4.926	3.23	4.29	Null hypothesis of no co-integration rejected at 1%

Source: Authors' compilation

Table 10 — Dependent Variable: ROA

Model selection method: Schwarz criterion (SIC)

Dynamic regressors (4 lags, automatic): RDI NWCR LEV

Selected Model: ARDL (1, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
ROA (-1)	0.4016	0.1550	2.5896	0.0158
RDI	0.5692	0.2675	2.1276	0.0417
NWCR	0.2567	0.1002	2.5621	0.0157
LEV	0.1270	0.0532	2.3855	0.0250
C	−0.0280	0.0267	-2.5081	0.0156
R-square	0.4748	Akaike info criterion		−5.1225
Adjusted R-squared	0.3908	Schwarz criterion		−4.8890
S.E. of regression	0.0173	Hannan-Quinn criter.		−5.0478
F-statistic	5.6521	Durbin-Watson stat		1.8339
Prob(F-statistic)	0.0022			

Source: Authors' compilation

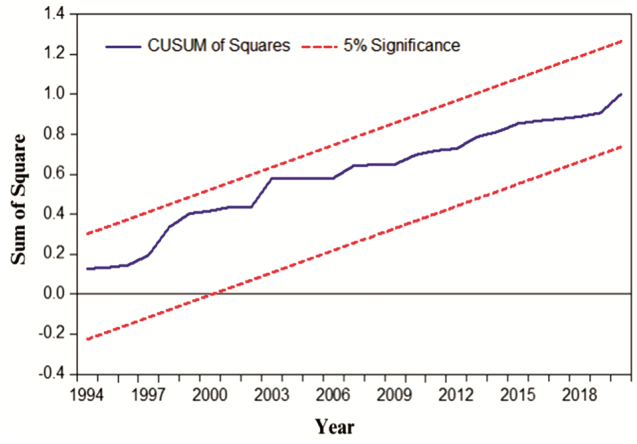

Fig. 2 — Plot of cumulative sum of squares of residuals (Source: Authors' compilation)

Table 11 — OLS Estimates and long-run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RDI	0.951356	0.41683	2.282316	0.046
NWCR	0.429153	0.12272	3.496782	0.000
LEV	0.212245	0.08872	2.392207	0.024

EC = ROA − (0.9514*RDI + 0.4292*NWCR + 0.2122*LEV) – long run error correction.

Source: Authors' compilation

Co-integrating Equation is-

$$D(ROA) = -0.0280 - 0.5983*ROA(-1) + 0.5692*RDI^{**} + 0.2567*(ROA - (0.9513*RDI(-1) + 0.4291*NWCR(-1) + 0.2122*LEV(-1)) + 0.1269*LEV^{**}) \quad \ldots (3)$$

There is an error correction of 59.836 % (Eq. 3). The error correction is highly significant (t-statistic value of 2.39220). Approximately 59.84% disequilibrium in ROA of IPI is corrected each year. In approximately seventeen months, ROA returns to its long run equilibrium.

R^2 value of 47.48%, suggests this model can predict 47.48% in the change in value of ROA of IPI (F-statistic value 4.926 & Durbin-Watson value of 1.8339). In the dynamic model (short run) all the variables are highly significant.

The model passed all the residual tests – no autocorrelation & heteroscedasticity present in residuals and normal distribution of residuals.

Model stability tests (CUSUM of squares), within the 5% (+/−) range do not show any instability of the model (Fig. 2).

OLS estimates (long run coefficient) of each variable are provided in Table 11. For every 1% rise in NWCR, the ROA increases by approximately 0.43% *ceteris paribus*. For every 1% rise in RDI, the ROA increases by approximately 0.95% *ceteris paribus*. For every 1% increase in LEV, the ROA increased by approximately 0.21% *ceteris paribus*.

The long run model suggests that RDI and ROA increase almost proportionately. This is quite possible since R&D investments lead to either high value addition in pharmaceutical products and/or cost containment in the manufacturing process. The positive sign of coefficient of NWCR indicates that increase in operations lead to increase in profitability. The positive sign of the coefficient of LEV indicates that an increase in debt leads to an increase in profitability.

A strong correlation (r = 0.94) is observed between debt to NP. Also, there is a strong GC (at 1 lag) from

Table 12 — Granger Causality

Null Hypothesis:	Obs	F-Statistic	Prob.
Lags: 1			
Debt ⟶ NP	30	7.31	0.011
Lags: 2			
NP ⟶ WC	29	8.38	0.001
NP ⟶ Debt	29	7.01	0.011
ROA ⟶ NWCR	29	8.48	0.001
RDI ⟶ LEV	29	3.63	0.042
NFA ⟶ WC	29	9.12	0.001
WC ⟶ NFA	29	9.35	0.001

debt to NP (Table 12). It can be interprete d that increase in debt results in a significant rise in NP after a year thereby favourably impacting ROA. A strong correlation (r = 0.96) is observed between NP and WC. Also, there is a strong GC (at 2 lags) from NP to WC. It can be interpreted that increase in NP results in significant rise in WC after two years thereby favourably impacting ROA.

GC is observed from RDI to NWCR at 1 lag (Table 6). Increased RDI requires higher operating capital so as to stay competitive, especially in Science and Technology-based industries. Strong GC is observed from ROA to NWCR at 2 lags and weak GC is observed from RDI to LEV at 2 lags (Table 12). Strong GC (at 2 lag) from NFA to WC and vice versa. It can be interpreted that increase in WC results in a significant rise in NP. Profitability is seen to impact operating capital levels in ensuing FY's. Though GC from RDI to LEV (debt/total assets) is weak, IPI as a whole is seen to be using debt to fund R&D expenditure thereby reflecting a change in approach to R&D; post 1995 accession to World Trade Organization.

Both VECM and ARDL results statistically confirm a long-run relationship between six variables, ROA, NWCR, LEV, NFAT, RDI and EXI in Indian pharmaceutical industry. Fifty percent of the variance in the forecasted of ROA after three years is cause by variation in physical capital intensity (NFAT), export intensity (EXI) and working capital intensity (NWCR). Long term relation of ROA is elastic to positive and significant change in NWCR and EXI. NFAT has a negative and significant relation with ROA. Impact of change in fixed assets on ROA is significantly higher than that of WC fluctuations. An evaluation of financial statements of more than top fifty firms (IPI) annually, shows that profitability has been intricately linked to liquidity. GC from NFAT to NWCR was observed at one year lag. Quite likely fixed assets require high operational capital after one year. GC from NFA to NP indicates that an increase in NFA leads to improved profitability after a year. GC from NWCR to EXI, on the other hand, denotes increasing WC allocation leading to increased exports, most likely due to larger credit sales, which also include exports.[36] With respect to ARDL model, ROA seems to be significantly influenced by RDI, NWCR and LEV. Replacement of two variables (NFAT & EXI) of VECM in ARDL, reduces the time taken attain to long-run equilibrium (in seventeen-months). Based only on the coefficients of NWCR and LEV in both ARDL and OLS estimates, it can be inferred that investment in WC is twice as beneficial to profitability as long-term debt. Also, investment in R&D is twice as productive to profitability as working capital intensity. GC from WC to NP is significant and there exists a positive relationship with them. Growth in NP produces a significant change in WC which leads to an increase in profitability.

Conclusions

From the co-integration models, it can be inferred that investments in fixed assets, operating capital and R&D influence return on assets in long run.

Strictly from financial constraints point of view, investing can be recommended for IPI in the order of priority as follows–

1) Increase in investment in WC.
2) Increase in investment in R&D.
3) Long term debt (subjected to prudence) can be used for investments.

Investment in fixed assets was shown to negatively impact ROA. Contribution of NFA to profitability needs to be looked through the mediating role played by NWCR. Only when usage of fixed assets is supported by increased operation, do fixed assets start contributing positively to ROA through working capital. Studies with asymmetric regressions may give different results at various lags. It must be noted that to finance fixed assets, very high levels of long-term investments will be required.

Taking these inferences into account, in the long run, IPI would require continuously large investments - this can lead to consolidation, maybe even amalgamation into MNCs. E.g., Abbott (MNC) acquired Piramal Pharmaceutical in 2010. Similarly acquisitions of Ranbaxy by SunPharma in 2015,

Lupin's acquisition of US-based Gavin 2015, Lupin' acquisition of Russian Biocom in 2015 etc. The study's findings suggest that IPI requires significant long-term investments to maintain its current level of ROA.

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