Productivity Growth, Technological Diffusion and Globalization – Cointegration and Causality

Surajit Sengupta (University of Burdwan, India) and Ratan Kumar Ghosal (University of Calcutta, India)

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Dr. Surajit Sengupta, Tarakeswar Degree College,University of Burdwan

Ratan Kumar Ghosal, Professor of Economics,

University of Calcutta, Kolkata, India.

Abstract

This paper examines the growth dynamics of the countries Israel and Japan in terms of the growth of per capita real income and the TFP growth for the period from 1980 to 2014 and the role of the technological improvement, globalization, the distance of the countries from the Global Productivity Frontier(GPF) as well as the Global Technology Frontier(GTF) and the financial development of the country concerned to this end. The long run relationship between the above factors coupled with their short run dynamics are estimated by applying time series econometrics to the data base which is basically secondary. It is found that in case of growth of per capita income the factors like financial development, distance of the countries from GTF, and globalization have a strong long-run causality with the growth. Analogously, the same factors along with the factor like the distance of the country from GPF are found to have long run equilibrium relation with the TFP growth of the countries such that in both the cases of growth the short run dynamics of the co-operant factors reveals the correction of deviations of the same from the long-run equilibrium path for both of the two countries. We conclude that the long run performance of the economies during the period from 1980 to 2014 supports the theoretical and empirical (cross-country analysis) findings of the modern endogenous growth theories developed in Schumpeterian growth framework and also the old hypothesis of Gerschenkron.

JEL Classification Nos: O31 ;O40, E 31

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The last four decades since the beginning of the process of globalization across the countries since 1970 have witnessed a tremendous competition for raising the productivity per worker of the manufacturing sector so as to achieve high rate of growth of GDP per capita. Actually, the liberalization of trade, as an outcome of the process of globalization has made not only the modern capital goods and consumer goods but also the advanced technology developed by the rich countries available within the ambit of the developing countries. In fact, there has been substantial increase in the rate of diffusion of modern technology (through technological externalities or spill over) across the developing countries such that such countries have been able to use the same and increase the rate of growth of their productivities. Thus

the contribution of the productivity growth to the growth of GDP seems to have acted as a key determinant to the observed growth dynamics across the countries. Moreover, the use of advanced technology which is basically labour savings and skill based, by the developing countries through the increasing expenditure on R&D seems also to have contributed to the growth of productivity per worker vis-à-vis that of GDP across the countries. However it is found that the use of the skill based advanced technology by the unskilled workers in the developing countries i.e. the technology –skill mismatch has often resulted in the lower productivity per unit of worker in the developing countries as compared to the developed counties who develop the new technology with their skilled labour (Acemoglu and Zilibotti, 2001). On the other hand, the continuous innovations of new advance technology by the developed countries have also helped raising their productivity growth as well as GDP growth per worker (GPCGDP). The empirical studies in this area have shown conflicting views regarding the total factor productivity growth such that there is controversy over the issue of relative contribution of labour, capital(in broader sense) and technology on the growth of the countries (Griliches,1994; Pritchett,2000; Young's,1995; Hsieh,2002; Caselli,2005; King and Levine,1994; Aghion and Howitt, 2009). In fact, the controversy centers round the relationship between growth accounting and causality and also the separation of the contribution of capital from that of technology, as most of the modern capital goods are embodied with advanced technology. So this calls for a study on the long run relationship between the growth of per-capita GDP and productivity per worker, globalization and technology diffusion across the countries in the globe.

Further there is cross current views regarding the role of R&D on the cross country variations in the growth of productivity of the countries since globalization. In some studies it is argued that R&D actually helps increase in the productivity of the countries in two ways: i) it helps stimulating innovations and ii) it enhances the technology transfer i.e. the absorptive capacity of the countries (Griffith et al.,2004; Levine et al.,2000). However, for the effectiveness of these two roles of R&D, liberalization of trade vis-à-vis the import plays a crucial role. Moreover, one cannot deny the fact that the advanced technologies which are basically skill based technologies requires not only adequate human capital but also the favorable tacit knowledge, improved human capital as well as improved culture. So for the absorption of modern technology and at the same time the innovation of improved technology on the part of the developing countries needs the development of all these factors. On the other hand, the innovation as well as the absorption of modern technology requires well developed financial systems also i.e. the banking structure, stock market etc. In fact, it is often found that the entrepreneurs producing goods and

services , not only in the developing countries but in the developed countries also, requires the financing for renovations of their mode of production through the application of the frontier technology in order to boost up their productivities and also to produce improved varieties of products. So, the producers are to be dependent on the financial structure of an economy. It has been found, that the countries having well developed financial institutions as well as stock market have experienced larger rate of growth of their productivities per worker in the industries as well as their per capita income as compared to the countries which have failed to develop their financial system (Levine et al., 2000; Rajan et al., 1998; Levine, 1997; Griffith et al.,2004). Therefore, one should take into account the role of the financial development as well as the growth of technology i.e. the increase in total factor productivity (TFP henceforth) across the countries in the globe. Further, there is some theoretical as well as empirical studies which emphasizes the distance of the countries from the global productivity frontier (GPF henceforth) as well as the global technology frontier (GTF henceforth) play crucial role towards the inducement of the countries for innovation as well as absorption of modern technology developed by the developed countries so as to catch up the GPF and GTF (Griffith , ; Levine,2000; Acemoglu and Zillibotti, 2001; Krugman,1987 ; Acemoglu, Zilliborti and Aghion, 2006, Ghosal,2007,2009, 2016). Therefore, what matter most are the relative positions of the countries in respect of per capita income as well as TFP in relation to the GPF and GTF. There is indeed a vast literature (theoretical and empirical) on the cross country variations in the growth, TFP (Levine et al.,2000, Rajan et al., 1998, Levine, 1997; Griffith et al., 2004, Acemoglu, Zilliborti and Aghion,2006; Acemoglue and Zilliborti, 2001) .But country specific macro level studiy on the productivity growth as well as the growth of real per capita income , by considering the relative positions of the countries and the productivity increasing role of R&D complimented by auxiliary explanatory factor like financial development, development of human capital etc , in a single model is still scarce and so we have made a country specific study which is based on time series econometric analysis.

Under this backdrop, we, in our study try to explain the role of all the factors not considered in the previous studies, on the growth of per capita income as well as TFP separately for two countries of which one is taken from developed countries and one from the developing countries by making time series analysis. The choice of these countries is done exclusively on the basis of availability of data series on all variables considered in our study**.** This paper is organized as

follows: Section- II discusses the econometric specification and the data base; Section -III analyses the results of the time series econometric analysis of Israel; Section -IV analyses the results of the time series econometric analysis of Japan and finally Section -V presents the concluding observations.

II. ECONOMETRIC SPECIFICATION AND DATA BASE

This section presents the econometric tools for the time series analysis which is used in our study. It is true that in case of any use of time series macro-economic data base for econometric analysis of the integration of the short run dynamics with long run equilibrium relationship between the variables one has to examine initially the stochastic property of the data set and then estimate the long run equilibrium relationship. In this study we have initially examined the stochastic property of data base by using of the econometric tools as follows:

In other words we have examined whether the data generating process is a stationary stochastic process or a non-stationary stochastic process before undertaking our estimation of long-run causality relationship between the series. We have done this by applying firstly the Augmented Dicky –Fuller (ADF) test and secondly the non- parametric alternative to ADF (as there is the problem of size distortion and low power in ADF) the Phillips and Perron (PP) test. We have incorporated both the intercept and trend component in ADF estimated relation as follows.

$$\Delta y_t = \alpha_t + \beta_t + \rho y_{t-1} + \sum_{i=1}^{p} \beta_i \gamma_i \Delta y_{t-1} + \varepsilon_t \text{ -------(1)}$$

The ADF statistic is the t-value associated with the estimated coefficient of ρ, the probability distribution of which is a functional of Weiner process which is used to explain the Brownian motion of a particle with large number of molecular shocks (Mddala and Kim, 1998**).** The PP test that we have used is actually a non-parametric extension of the DF unit root test through the addition of a correction factor to the DF t-statistic. We have done both of the tests for all the logarithmic values of the series of indices and also for their first differences, by choosing the lag length in terms of the Akaike Information Criterion (AIC). After conducting the unit –root tests for examining the stationarity of the series, we have estimated the long-run causal relationship

between the stationary series of our indices by applying the tests for cointegration and the estimation of cointegrating relationships (i.e. Engle and Granger (1987**)** tests. Engle and Granger have shown that if two series are cointegrated then there will be a causal long run relation between the series in at least one direction. This helps to integrate the short-run dynamics with the long-run equilibria so that our indices move together over time. Again to capture the short – run dynamics of disequilibria we have applied the vector error correction model (ECM) which helps correcting the past periods disequilibrium. The analysis of short-run dynamics is done by first eliminating trends in the variables by taking the difference. This process is likely to give us a more potential valuable information about long-run relationships between the indices(variables) In fact the Granger .representation theorem explains the process of modeling the cointegrated I(1) series in the form of Vector Auto regression(VAR) such that it can be constructed either in terms of levels(logarithmic values) of the data series following I(1) or in terms of their first differences, the I(0) variables/ data series, with the addition of an Error Correction Mechanism(ECM) to capture the short run dynamics.

For any two variables X and Y the model can be presented in the following forms of equations (2 to5) such that the equations 4& 5 incorporate the ECM.

$$\ln Y_t = \alpha + \sum_{i=1}^{m} \beta_i \ln X_{t-i} + \sum_{j=1}^{n} \gamma_i \ln Y_{t-j} + u_t \quad \text{.....(2)}$$

$$\ln X_t = \mu + \sum_{i=1}^{p} \pi_i \ln X_{t-i} + \sum_{j=1}^{r} \xi_j \ln Y_{t-j} + v_t \quad \text{.....(3)}$$

$$\Delta \ln Y_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta \ln X_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta \ln Y_{t-j} + \psi ECM_{t-1} + u_t \quad \text{----------(4)}$$

$$\Delta \ln X_t = \mu + \sum_{i=1}^{p} \pi_i \Delta \ln X_{t-i} + \sum_{j=1}^{r} \xi_j \Delta \ln Y_{t-j} + \chi ECM_{t-1} + v_t \quad \text{---------- (5)}$$

Where u_t and v_t are the random disturbances with zero mean and they are serially uncorrelated; ECM represents the error correction mechanism for capturing short run dynamics.

When the dependent variable is not co-integrated with independent variables one can examine the short run dynamics between them by utilizing the unrestricted VAR structure as shown in terms of equations (6) & (7). By incorporating one period lag as suggested by the minimum AIC rules the bi-variate structure is to be used and it takes the following form:

$$\Delta \ln Y_t = \beta_0 + \beta_1 \Delta \ln X_{t-1} + \beta_1 \Delta \ln Y_{t-1} + \varepsilon_{1t} \text{ ----------(6)}$$

$$\Delta \ln X_t = \alpha_0 + \alpha_1 \Delta \ln X_{t-1} + \alpha_2 \Delta \ln Y_{t-1} + \varepsilon_{2t} \text{ ---------- (7)}$$

Here in the equations the lagged form of the logarithmic values of X and Y are the explanatory variables in the VAR structure such that the coefficients of these two actually captures the short run dynamics , the signs of which indicate the nature of causal relation between the two series. If the coefficients are found to be statistically significant the relation of causality holds. However, our study is a multivariate one.

Data Base.

This study is exclusively based on the secondary data on the variables used in our study which are available from various sources. In our study we have actually tried to examine the equilibrium relationship between first, the growth of per capita real GDP (PCGDP) as dependent variable and globalization measured in terms of trade openness (TDOP), market capitalization (MKTCAP), research and development (RD), domestic credit provided by the financial sector scaled by GDP (DCP), relative positions of the countries in relation to the global productivity frontier (GPF) i.e. the distance of the country from the global productivity frontier which is measured in terms of the ratio of highest TFP of the OECD countries to the TFP of the country concerned over the period of our study. In fact, it is assumed that the distance of the country concerned from the global technology frontier (GTF) will contribute towards the inducement of the country to increase her per capita income over the period so as to catch up the GPF as well as GTF. Further, it is worth noting that since the theoretical as well as empirical literature on growth theory analysis emphasizes the role of financial development in the growth dynamics we have used financial development measured in terms of DCP and MKTCAP as explanatory

variables in our study in view of the estimation of their long run relationship with the growth of PCGDP of the country. Second, we have tried to estimate the long run relationship between the total factor productivity growth (LDTFP) which is treated as dependent variable and the globalization measured in terms of trade openness (TDOP), financial development (DCP, MKTCAP), research and development scaled by GDP (RD) and the relative position of the country concern in relation to the GPF which is measured in terms of the ratio of the PCGDP of the country concern over the time to the US PCGDP for 1980. Here we have assumed the US represents the global productivity level as is also used by others (Aghion and Howitt, 2009). We have used the PCGDP of the US for the year 1980 as the GPF, as our study period ranges from 1980 to 2014. In fact it is evident from the theoretical and empirical growth literature that the further the countries from the GPF faster will be the growth of productivity or per capita income of the country. There is an old hypothesis which is known as Gerchenkron's hypothesis (1962) in this respect. We have also use logarithmic values of all variables. Now, since all the logarithmic values of the variables are found to be non stationary (i.e. each of them contains unit root) in their levels and stationary in their first differences we have taken the first differences of their logarithmic values in estimating the long run relationship between the variables. To test the stationarity of the data series we have used Augmented Dickey-Fuller(ADF) and Phiiips-Perron (PP) test. Further, since the series are not stationary at their level but stationary at their first difference we have reported the test statistic (Augmented Dickey-Fuller and Phiiips-Perron) only at their first differences.

Now as far as the sources of data are concerned we have taken the data on TFP from the Penn World table 9.0 version. The other data series like PCGDP, DCP, MKTCAP, TDOP, R&D are taken from various reports of World Development Indicators, UNESCO data base and BERD data base. For estimating the two sets of long run relationship between the variables stated above we have chosen 1980 to 2014 as the period of our time series analysis. For the analysis we have purposively selected two countries one from developing country i.e. Israel and the other from the developed country i.e. Japan. Again, it is to be stated that all the variables are at constant GDP US$ ppp. We have used the econometric software E-Views 6.1 version for the econometric analysis of our study.

III. ANALYSIS OF THE RESULTS OF ECONOMETRIC EXERCISE FOR ISRAEL

This section is devoted to the analysis of the growth of per capita income and the TFP growth of the country Israel during the period from 1980 to 2014. The average performance of the country in respect of our variables is given in table-1. It follows from the table that there is wide difference between the minimum average of PCGDP and the maximum average of the same over the period. Surprisingly, in case of index of globalization TDOP, TFP, DCP and human capital (HC) we also find substantial differences between the maximum and minimum values. What is interesting is that the cross time variability of income (measured in terms of standard deviation) in Israel is very high over the period of our study. Similar picture is found to persist in case of globalization and DCP. So, from the average performance of Israel in respect these parameters it is observable that there is also wide short run fluctuation in the average performance.

Table-1: Summary Statistics on average performance of Israel During 1980-2014.

Variable	Obs	Mean	Std. Dev.	Min	Max
pcgdp	35	17493.1	4458.031	11357.05	24540.58
tdop	35	77.84267	12.88017	59.79723	103.1153
dcp	35	103.2033	36.75816	70.49247	232.08
tfp	35	.9258571	.0508959	.8295054	1.000699
hc	35	3.2644	.212085	2.918633	3.687228
rd	35	2.662713	1.451026	.612282	4.407447

Now the result of the test of stationarity of data which are given in appendix table-1 clearly reveals that both for ADF and PP test for the hypothesis that there is the presence of unit root is rejected as the values of the test statistic in both the cases exceeds the critical values at 1% and 5% level. So the results of the stationarity tests confirm the data series follow I(1) series and so they are conintegrated. Now, since the ADF and PP test statistics reveal that PCGDP and all other variables like TDOP, RD, RTFP, DCP series are integrated in order one, we may have the long run relations between them through co integration. So for capturing the causality and long run relationship between the variables we have estimated the co-integrating relationship between the series by applying Johansen's co-integrating test. We have estimated both the trace test i.e. the LR test (likelihood ratio test) and the maximum Eigen values test. The estimated statistics of co-integration test for the relation between PCGDP growth and all other independent variables are given in table-2a and 2b. Table 2a represents the trace statistics and table-2b shows the maximum eigen values. Trace statistics clearly indicates the there is almost five co-integrating equations at 5% level of significance for all the series. Further, the likelihood statistics corresponding to the eigen values given in table-2b which are actually used to test the hypotheses of the presence of long run equilibrium relationship between the series against the alternative hypothesis of full rank indicate that the likelihood values are greater than the critical values at 5% for the null hypothesis such that the hypothesis of the absence of the co-integrating equation in the model is rejected. So it follows from the table that the null hypothesis of the presence of no co-integrating equations are rejected by both the tests. Therefore, it can be plausible to say that the growth of per capita income and the other variables like TDOP, DCP, MKTCAP, RD, RTFP are co-integrated. It is interesting to note that in this case the relative positions of the country in relation to global technology frontier has a strong causality to the growth of per capita income and it is evident from the cointegrating equation which is not reported here.. The robustness of this result is established by the coefficient and the standard error of growth of LRTFP (LDRTFP).

TABLE-2A : Estimated statistics of co integration test (trace test) for growth of log PCGDP and other variables in Israel

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.770246	123.7020	69.81889	0.0000
At most 1 *	0.593813	76.63811	47.85613	0.0000
At most 2 *	0.560285	47.80794	29.79707	0.0002
At most 3 *	0.406937	21.51585	15.49471	0.0055
At most 4 *	0.139219	4.797303	3.841466	0.0285

Source : Authors' computation .

TABLE-2B: Estimated statistics of cointegration test(maximum eigen value) for growth of log PCGDP and other variables in Israel

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.770246	47.06385	33.87687	0.0008
At most 1 *	0.593813	28.83017	27.58434	0.0345
At most 2 *	0.560285	26.29209	21.13162	0.0086
At most 3 *	0.406937	16.71854	14.26460	0.0201
At most 4 *	0.139219	4.797303	3.841466	0.0285

Source : Authors' computation .

On the other hand, to capture the short run dynamics of the relationship between the growth of PCGDP and the other variables considered above, i.e. to examine whether there is any short run

variability caused by any shocks are being corrected and the nature of the role of the co- operant factors to this end, we have applied Granger representation theorem i.e. the vector error correction model in VAR structure. We have estimated the vector error correction model as stated in equation 4 and 5 such that the signs of the error correction parameters indicate whether the short run disequilibrium due to external shocks are being corrected. Results of the VER model represent in appendix table-2. It is found that in most of the cases the error correction parameters are negative and significant excepting in case of RD which bears a positive sign. So, this clearly indicates the short run disequilibrium due to external shocks is being corrected so that the series converges with the long run equilibrium path. However, in case of R&D we find that the short run disequilibrium due to external shocks is not being corrected so as to reach the long run equilibrium path of RD. In other word, the short run dynamics is not being captured in this case. The economic logic behind this phenomenon can be outlined as follows. In fact the technological innovations is not a static process rather it's a dynamic process i.e. the innovation of one technology at a particular time becomes redundant after a few years, when there is a new innovation for the production of the same product vis-à-vis for new products so that the old technology as well as the old products becomes redundant. So the RD through it two effects (the innovation stimulating and the absorptive) basically is a dynamic process and so the short run shocks to the long run equilibrium relation may not necessarily be corrected. It seems that this has happened in case of Israel's economy.

On the other hand, if we look at the growth of the total factor productivity and its long run relationship with DCP, MKTCAP, LRPCGDP, RD, TDOP, we also find almost the same results. Before undertaking the time series analysis we have once again examine the stochastic properties of the series of data set by applying the ADF and PP tests of stationarity, the results of which are given in appendix table-1. Once again it follows that the logarithmic values of the series are non-stationary at their level but stationary at their first differences. So, the results of ADF and PP statistics confirm that there exist long run equilibrium relationships between the variables such that they could be co-integrated. Therefore, to examine the long run equilibrium relationship between the variables we have done Johansen's co-integration test (i.e. the LR test or trace test and the maximum Eigen values), the econometric results of which are given in table-3A and 3B. It is interesting to note that both the trace statistic and maximum Eigen values reveal that there are almost five cointegrating equations at the 0.05 level of significance. The robustness of this

result is established by the respective p-values in table 3A and 3B. So, it is plausible to conclude that there is long run equilibrium relationship between the growth of TFP and those of the LRPCGDP, TDOP, MKTCAP, RD. However, it is worth mentioning that the relative positions of the Israel in relation to the GPF measured in terms of RPCGDP has helped boosting the growth of TFP which is reflected by the negative signs of the coefficients in the cointegrating equations (not reported here). So, our results support the Gerschenkron's hypothesis that further a country from GPF faster will be the growth of its productivity such that it holds for time series also.

Table 3A: Estimated Statistics of cointegration (Trace) for growth of LTFP in Israel

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.775483	121.5647	69.81889	0.0000
At most 1 *	0.592388	73.76292	47.85613	0.0000
At most 2 *	0.541449	45.04488	29.79707	0.0004
At most 3 *	0.378642	20.09497	15.49471	0.0094
At most 4 *	0.141114	4.867825	3.841466	0.0274

Source : Authors' computation .

Table 3B: Estimated Statistics of cointegration test (maximum Eigen value) for growth of LTFP in **Israel**

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.775483	47.80176	33.87687	0.0006
At most 1 *	0.592388	28.71804	27.58434	0.0357
At most 2 *	0.541449	24.94991	21.13162	0.0138
At most 3 *	0.378642	15.22714	14.26460	0.0351
At most 4 *	0.141114	4.867825	3.841466	0.0274

Source: Authors'Computation

Now, to examine the short run dynamics of the behavior of the growth of TFP coupled with the growth of other co operant variables and to see whether the short run exogenous shocks lead to correct the short fall from the long run steady state path so that the dynamics of the variables once again lead the convergence with the long run equilibrium path, we have made Vector error correction estimate (VEC) in VAR structure, the results of the estimates along with their t-statistic are represented in appendix table-3. The table reports that in case of MKTCAP the short run disequilibria caused by exogenous shocks is being corrected and it is reflected by the statistically significant negative signs of the variables**.** However, in case of RD, RPCGDP and Globalisation short deviations from the long run equilibrium are not being corrected in one period lag. So, on the whole, we can say that both in case of growth of PCGDP and that of TFP there exist long run equilibrium relations between the variables under considerations. Interestingly, the relative positions of the countries i.e. the distance of the country from the GTF and GPF makes economically and statistically significant positive contribution towards the growth of per capita income and TFP growth across time over the period of our study i.e. since globalization. Further, the short run dynamics of the variables clearly indicate that the deviations of the variable from their long run equilibrium path are mostly being corrected in case of growth of per capita income of Israel but this does not hold entirely in case of TFP growth.

IV. **ANALYSIS OF THE RESULTS OF ECONOMETRIC EXERCISE FOR JAPAN**

This section presents the time series econometric analysis of the growth of PCGDP and TFP as well as their cooperant factors for the country Japan during the period from 1980 to 2014. Analogous to our previous analysis of Israel , here also we have rigorously examined two sets of long run equilibrium relationship along with their short run dynamics. The first one examines the long run relationship between the growth of per capita income and that of globalization (TDOP), relative positions of Japan in relation to GTF (RTFP), financial development (MKTCAP, DCP) and research and development(RD) over the period of 35 years since 1980. On the other hand the second one estimates the long run relationship between the growth of TFP and that of other cooperant factors i.e. distance of the country from GPF (RPCGDP), TDOP, MKTCAP, DCP, RD. Here also before estimating the long run relationship coupled with short run dynamics we have examined the average performance of Japan in respect of trade, financial development, net

capital formation, TFP, human capital(HC) and RD during the period of our study and this is presented in terms of summary statistics in table-4 below.

Table 4: Summary Statistics of the Variables on Japan

Variable	Obs	Mean	Std. Dev.	Min	Max
pcgdp	35	31744.9	5061.207	20962.92	37595.18
tdop	35	24.02207	6.312995	15.92399	38.5522
dcp	35	279.6545	48.6966	185.6644	373.7896
mktcap	35	73.57452	25.48851	31.5627	141.2101
tfp	35	1.017723	.0280758	.9706371	1.07925
hc	35	3.287974	.1651388	3.00522	3.539959
ncf	35	1.10e+07	5130614	2516514	1.72e+07
rd	34	2.900814	.41765	2.076791	3.588317

Source: Authors' Computation .

The overview of the performance given in table-4 clearly reveals the substantial differences between the maximum and minimum values of all the parameters excepting human capital. This clearly indicates that Japan has maintained a strong and consistent base of human capital over the period. However, the cross time variability of per-capita income, financial development and net capital formation are found to be very high with their average performance being consistent with their maximum and minimum values. Prior to estimate the long run relationship between the variables stated above we have once again examined the stochastic properties of the data series on the variables in terms of ADF and PP test, the results of which are given in the appendix table-1. It is found that the series in their logarithmic values are non-stationary at their levels (for

which the ADF and PP test statistics are not reported in the table) but they are stationary at their first differences (such that the lag lengths are chosen by AIC) and it is confirmed by the stress statistic along with their probabilities (results are reported in appendix table).

Having done so we proceed to estimate the long run relationship between the variables by applying Johansen's co integration test i.e. unrestricted co integration rank test (trace test) and the test of maximum eigen value. The test statistics are given in Table 5A and 5B. Table 5A represents the trace statistics and table-5B shows the maximum eigen values. Trace statistics clearly indicates the there is at most two co-integrating equations at 0.05 level of significance for all the series. Further, the likelihood statistics corresponding to the eigen values given in table-5B which are actually used to test the hypotheses of the presence of long run equilibrium relationship between the series against the alternative hypothesis of full rank indicate that the likelihood values are greater than the critical values at 0.05 level of significance for the null hypothesis such that the hypothesis of the absence of the co-integrating equation in the model is rejected. So it follows from the table that the null hypothesis of the presence of no co-integrating equations are rejected by both the tests. Therefore, it is plausible to say that the growth of per capita income and the other variables like TDOP, DCP, MKTCAP, RD, and RTFP are co-integrated. It is interesting to note that in case of Japan, its relative positions in relation to global technology frontier have a strong positive causality to the growth of per capita income. The robustness of this result is established by the statistically significant coefficient backed by the standard error of the coefficient of growth of LRTFP (LDRTFP) and it is evident from the co integrating equation (not reported here). It is interesting to note that this result also supports Gerschenkron's hypothesis. Moreover it is also plausible to conclude that the technological progress has helped positively to boost the growth of per capita income of Japan.

Now, we examine the short run dynamics of the behavior of the growth of per capita income over the period coupled with the growth of other co operant variables and see whether the short run exogenous shocks lead to correct the short fall from the long run steady state path so that the dynamics of the variables once again lead the convergence with the long run equilibrium path. To this end, once again we have made Vector error correction estimate (VEC) in VAR structure, the results of the estimates along with their t-statistic is presented in appendix table-4. It follows from the cointegrating equation (not reported here) that excepting the variable RTFP

all other variables have negative coefficients such that the coefficient of globalization is significant and that of the relative position of the country in relation to GTF i.e. (RTFP), the coefficient of which is positive and also significant. So, it is plausible to say that in Japan the development of technology has played the role of encouraging factor towards the catching up of the GTF. In this respect one can also say that this result supports the view of the modern endogenous Schumpeterian growth theories and empirical studies (Aghion and Howitt, 2006; Levine et al. 2000; Griffith et al. 2004). Further, it follows from the table that almost all the coefficients of vector error correction estimates are negative with those of RTFP, RD and DCP being significant. So, we can say that the short run deviations of these factors from the long run equilibrium path due to the exogenous shocks are being corrected so that the short run dynamics of the factors like domestic credit, RD and the relative positions of the country lead to converge towards the long run equilibrium path. The reality in case of Japan also tells so**.** It is true that the human capital in Japan which is rich enough such that the same seems to have made substantial contribution to this long run dynamic process of growth. Since the data on human capital which are available in the form of human capital index, have the non stationary property, we could not incorporate the variable in our study.

Table5A: Estimated Statistics of Cointegration (Trace) for growth of LPCGDP in Japan

Hypothesized		Trace		
No. of CE(s)	Eigenvalue	Statistic	5% Critical Value	Prob.**
None *	0.715243	114.8137	95.75366	0.0013
At most 1 *	0.590107	74.61791	69.81889	0.0197
At most 2	0.472677	46.07844	47.85613	0.0728
At most 3	0.348040	25.60027	29.79707	0.1411
At most 4	0.259613	11.91156	15.49471	0.1612
At most 5	0.069147	2.292934	3.841466	0.1300

Source : Authors' computation

Table5B: Estimated Statistics of Cointegration (Eigen Value) for growth of LPCGDP

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.715243	40.19580	40.07757	0.0485
At most 1	0.590107	28.53948	33.87687	0.1897
At most 2	0.472677	20.47817	27.58434	0.3090
At most 3	0.348040	13.68871	21.13162	0.3911
At most 4	0.259613	9.618626	14.26460	0.2382
At most 5	0.069147	2.292934	3.841466	0.1300

Source : Authors' computation

Now we turn to analyze the long run dynamics of the TFP, along with its co-operant factors coupled with that of its nature of short run variability. In this respect also before undergoing the econometric analysis we have tested the stochastic property of all the data series by applying GTF and PP test, the results of which are given in appendix table-1. It is once again worth mentioning that all the series are found to have non-stationary properties in the logarithmic values of their level (results not reported) but the series follow the stationary property at their first differences (results reported in the table). The robustness of these results is established by their corresponding p-values. Now, to examine the long run equilibrium relationships the growth of TFP with those of DCP, RPCGDP, MKTCAP, RD and TDOP, we have estimated Johansen's unrestricted cointegration test (trace test and maximum eigen value)with the assumptions of linear deterministic trend. The test results are reported in table 6A and 6B below. The critical values of the trace statistics and the maximum eigen values at their 0.05 level of significance supported by their respected probabilities clearly reveal that there is at least one co-integrating equation at 0.05 level. So, one can plausibly conclude that there exists long run casualty between the growth of TFP and financial development, RD, distance of the country from GPF.

Table6A: Estimated Statistics of Cointegration (Trace) for growth of LRTFP

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.715243	114.8137	95.75366	0.0013
At most 1 *	0.590107	74.61791	69.81889	0.0197
At most 2	0.472677	46.07844	47.85613	0.0728
At most 3	0.348040	25.60027	29.79707	0.1411
At most 4	0.259613	11.91156	15.49471	0.1612
At most 5	0.069147	2.292934	3.841466	0.1300

Source: Author's Computation

Table6B: Estimated Statistics of Cointegration (Eigen Value) for growth of LRTFP

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.715243	40.19580	40.07757	0.0485
At most 1	0.590107	28.53948	33.87687	0.1897
At most 2	0.472677	20.47817	27.58434	0.3090
At most 3	0.348040	13.68871	21.13162	0.3911
At most 4	0.259613	9.618626	14.26460	0.2382
At most 5	0.069147	2.292934	3.841466	0.1300

Source: Author's Computation

Now to see whether the short run fluctuations in the variables are corrected towards the long run equilibrium path we have estimated a vector error correction model following the econometric specification given in section-II in terms of equation (4) and (5). The results of this error correction estimates are given in appendix table-5. The overview of the appendix table clearly reveals that the coefficients of DCP, MKTCAP, RD and globalization are negative such that the t-statistics confirms this statistical significance of the coefficients of TFP, DCP, RPCGDP

(which is positive) and RD. So, we can plausibly conclude that the short run deviations of the variables TFP, DCP, RPCGDP,RD are being corrected so that over time the movement of the values of the variables converge with the long run equilibrium path. Interestingly, the positive sign of the coefficient RPCGDP clearly indicates (as in the ratio US PCGDP 1980 is used as denominator) that Japan has been trying to catch up the GFP in the long run, nevertheless there is short run variations. On the whole, the time series econometric analysis of the Japan's economy in respect of its growth of per capita income and TFP as well as the co-operant factors like financial development, RD and the distance of the country from both GPF and GTF clearly reveals that there is long run equilibrium relationship between the above variables during the period of our study and in most of the cases the short run deviations of the factors from long run equilibrium path have also been corrected so that all the variables are moving along a long run equilibrium path. What is interesting is that Japan has also been trying to catch up the GPF and GTF with the development of their co-operant factors like the development of RD and financial institutions. So the long run performance of Japan's economy during the period from 1980 to 2014 supports the theoretical and empirical (cross-country analysis) findings of the modern endogenous growth theories developed in Schumpeterian growth framework and also the old hypothesis of Gerschenkron.

Section V. Concluding Observation

This paper examines the growth dynamics of the countries Israel and Japan in terms of the growth of per capita real income and the TFP growth for the period from 1980 to 2014 and the role of the technological improvement, globalization, the distance of the countries from the Global Productivity Frontier(GPF) as well as the Global Technology Frontier(GTF) and the financial development of the country concerned to this end. The long run relationship between the above factors coupled with their short run dynamics are estimated by applying time series econometrics to the data base which is basically secondary. The major findings of our study can be outlined as follows.

First, the average performance of the two countries as is indicated by the summary statistics indicates that there has been wide cross time variations in the maximum and the minimum values of almost all the variables. In most of the cases the cross time variations are significant.

Interestingly, it is found that Japan has been able to maintain a strong and consistent base of human capital over the period.

Second, as far as the case of Israel we conclude that there is long run equilibrium relationship between the growth of TFP and those of the LRPCGDP, TDOP, MKTCAP, RD. However, it is worth mentioning that the relative positions of the Israel in relation to the GPF measured in terms of RPCGDP has helped boosting the growth of TFP which is reflected by the negative signs of the coefficients in the cointegrating equations (not reported here). So, our results support the Gerschenkron's hypothesis that further a country from GPF faster will be the growth of its productivity such that it holds for time series also. In case of growth of per capita income also we find almost same result. However, in case of RD, RPCGDP and Globalisation short run deviations from the long run equilibrium path are not being corrected in one period lag. So, on the whole, we can say that both in case of growth of PCGDP and that of TFP there exists long run equilibrium relations between the variables under considerations. Interestingly, the relative positions of the countries i.e. the distance of the country from the GTF and GPF makes economically and statistically significant positive contribution towards the growth of per capita income and TFP growth across time over the period of our study i.e. since globalization. Further, the short run dynamics of the variables clearly indicate that the deviations of the variable from their long run equilibrium path are mostly being corrected in case of growth of per capita income of Israel but this does not hold entirely in case of TFP growth.

Finally in case of Japan the development of technology has played the role of encouraging factor towards the catching up of the GTF. In this respect one can also say that this result supports the view of the modern endogenous Schumpeterian growth theories and empirical studies (Aghion and Howitt, 2006; Levine et al. 2000; Griffith et al. 2004). Further, it follows from the table that almost all the coefficients of vector error correction estimates are negative with those of RTFP, RD and DCP being significant. So, we can say that the short run deviations of these factors from the long run equilibrium path due to the exogenous shocks are being corrected so that the short run dynamics of the factors like domestic credit, RD and the relative positions of the country lead to converge towards the long run equilibrium path. that the short run deviations of the variables TFP, DCP, RPCGDP,RD are being corrected so that over time the movement of the values of the variables converge with the long run equilibrium path.

Interestingly, the positive sign of the coefficient RPCGDP clearly indicates (as in the ratio US PCGDP 1980 is used as denominator) that Japan has been trying to catch up the GFP in the long run, nevertheless there is short run variations. On the whole, the time series econometric analysis of the Japan's economy in respect of its growth of per capita income and TFP as well as the co-operant factors like financial development, RD and the distance of the country from both GPF and GTF clearly reveals that there is long run equilibrium relationship between the above variables during the period of our study and in most of the cases the short run deviations of the factors from long run equilibrium path have also been corrected so that all the variables are moving along a long run equilibrium path. What is interesting is that Japan has also been trying to catch up the GPF and GTF with the development of their co-operant factors like the development of RD and financial institutions. So the long run performance of Japan's economy during the period from 1980 to 2014 supports the theoretical and empirical (cross-country analysis) findings of the modern endogenous growth theories developed in Schumpeterian growth framework and also the old hypothesis of Gerschenkron. Interestingly it follows from our study that the distance of the countries from the GPF and GTF as well as the financial development play economically and statistically positive role towards the long run growth of per capita income and TFP growth of the countries coupled with their short run

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APPENDIX TABLE-1: Estimated statistics of unit root tests

SERIES	ISRAEL		JAPAN	
	ADF	PP	ADF	PP
LDPCGDP	-4.713696	-4.674738	-4.835058	-4.835058
LDTDOP	-5.620746	-5.798819	-5.386966	-6.025796
LDDCP	-4.146023	-3.915014	-5.735115	-5.885446
LDMKTCAP	-3.716135	-13.00439	-4.795051	-4.713381
LDRD	-4.999713	-4.998229	-4.357728	-4.387828
LDRTFP	-5.329659	-9.569997	-5.614934	-5.613116
LDRPCGDP	-4.746227	-4.673511	-4.835058	-4.835058
LDTFP	-5.329659	-9.569997	-5.614934	-5.613116
CRITICAL VALUES				
1% LEVEL	-4.262735	-4.262735		
5% LEVEL	-3.552973	-3.552973		
10% LEVEL	-3.209642	-3.209642		

Appendix table 2: Estimates of Vector Error Correction Model of Israel

Independent variables	Dependent variables				
	D(LDPCGDP)	D(LDLRTFP)	D(LDMKTCAP)	D(LDRD)	D(LDTDOP)
ECM	-0.77859	0.218683	0.157408	1.126883	-0.97997
	[-3.91442]	[1.91128]	[0.05268]	[1.49009]	[-1.51946]
D(LDPCGDP(-1))	-0.069169	-0.036469	-5.359597	-1.215805	-0.370496
	[-0.28898]	[-0.26487]	[-1.49063]	[-1.33597]	[-0.47737]
D(LDLRTFP(-1))		0.231025			
		[0.67348]			
D(LDMKTCAP(-1))			-0.671440		
			[-1.63936]		
D(LDRD(-1))				-0.822460	
				[-3.80028]	
D(LDTDOP(-1))					-0.481124
					[-2.07596]
C	-0.00224	0.000529	0.015916	0.000174	
	(0.00619)	(0.00356)	(0.09298)	(0.02353)	(0.02007)
	[-0.36185]	[0.14847]	[0.17118]	[0.00738]	[-0.00562]
R-squared	0.615721	0.664286	0.630417	0.650555	0.489695
Adj. R-squared	0.393243	0.469926	0.416447	0.448245	0.194255
F-statistic	2.767566	3.417806	2.946293	3.215631	1.657510
Log likelihood	68.17109	85.31303	-15.82323	26.76879	31.70417
Akaike AIC	-3.623941	-4.729873	1.795047	-0.952825	-1.271237
Schwarz SC	-3.068849	-4.174781	2.350139	-0.397733	-0.716145

Source: As for table 2A and 2B (figures in square brackets indicate t-values)

Appendix Table 3: Estimates of Vector Error Correction Model of Israel

	Deoendent variables				
Independent variables	D(LDTFP)	D(LDLRPCGDP)	D(LDMKTCAP)	D(LDRD)	D(LDTDOP)
ECM	-0.563552	-1.21888	0.606942	2.161389	-1.91112
	[-2.36955]	[-4.68131]	[0.09395]	[1.31127]	[-1.34542]
D(LDTFP(-1))	0.210418				
	[0.68150]				
D(LDLRPCGDP(-1))		-0.024691			
		[-0.11355]			
D(LDMKTCAP(-1))			-0.659828		
			[-1.66683]		
D(LDRD(-1))				-0.875922	
				[-3.57045	
D(LDTDOP(-1))					-0.462007
					[-2.00585]
C	-0.000608	-0.001437	0.017723	0.000355	0.000580
	[-0.17740]	[-0.38323]	[0.19045]	[0.01494]	[0.02835]
R-squared	0.689469	0.672492	0.630143	0.644604	0.470064
Adj. R-squared	0.509687	0.482882	0.416015	0.438848	0.163259
F-statistic	3.835039	3.546712	2.942832	3.132861	1.532127
Log likelihood	86.52162	83.71451	-15.83471	26.50704	31.11909
Akaike AIC	-4.807846	-4.626743	1.795788	-0.935938	-1.23349
Schwarz SC	-4.252754	-4.071651	2.350880	-0.380846	-0.678398

Source: As for table 2A and 2B (figures in square brackets indicate t-values)

Appendix Table 4: Estimates of Vector Error Correction Model of Japan

	dependent Variables					
Independent Variables	D(LDPCGDO)	D(LDDCP)	D(LDMKTCAP)	D(LDRD)	D(LDRTFP)	D(LDTDOP)
ECM	-0.399911	-0.121811	-2.950496	-0.035148	0.335508	-1.736032
	[-2.14968]	[-0.35812]	[-1.22510]	[-0.14574]	[2.54003]	[-1.66104]
D(LDPCGDO(-1))	0.916608					
	[1.29897]					
D(LDDCP(-1))		-0.699417				
		[-1.79506]				
D(LDMKTCAP(-1))			-0.281861			
			[-0.89910]			
D(LDRD(-1))				-0.423073		
				[-1.22571]		
D(LDRTFP(-1))					-1.106644	
					[-1.96983]	
D(LDTDOP(-1))						-0.008864
						[-0.01684]
C	-0.000119	-0.001999	-0.005655	-0.000786	-0.000272	0.013466
	[-0.02858]	[-0.26325]	[-0.10517]	[-0.14595]	[-0.09221]	[0.57708]
R-squared	0.636160	0.538600	0.532405	0.542652	0.677663	0.578635
Adj. R-squared	0.357930	0.185765	0.174833	0.192915	0.431171	0.256414
F-statistic	2.286450	1.526493	1.488944	1.551599	2.749224	1.795773
Log likelihood	82.75482	64.04812	3.370576	74.70838	93.37100	29.24922
Akaike AIC	-4.435795	-3.228911	0.685769	-3.91667	-5.12071	-0.983821
Schwarz SC	-3.788188	-2.581304	1.333376	-3.269063	-4.473103	-0.336214

Source: As for table 5A and 5B (figures in square brackets indicate t-values)

Appendix Table5: Estimates of Vector Error Correction Model of Japan

	Explained Variables					
Explanatory Variables:	D(LDTFP)	D(LDDCP)	D(LDLRPCGDP)	D(LDMKTCAP)	D(LDRD)	D(LDTDOP)
ECM	-0.283021	-0.102755	-0.33735	-2.488924	-0.02965	-1.46445
	[-2.54003]	[-0.35812]	[-2.14968]	[-1.22510]	[-0.14574]	[-1.66104]
D(LDTFP(-1))	-1.106644					
	[-1.96983]					
D(LDDCP(-1))		-0.699417				
		[-1.79506]				
D(LDLRPCGDP(-1))			0.916608			
			[1.29897]			
D(LDMKTCAP(-1))				-0.281861		
				[-0.89910]		
D(LDRD(-1))					-0.423073	
					[-1.22571]	
D(LDTDOP(-1))						-0.008864
						[-0.01684]
C	0.000272	-0.001999	-0.000119	-0.005655	-0.000786	0.013466
	[0.09221]	[-0.26325]	[-0.02858]	[-0.10517]	[-0.14595]	[0.57708]
R-squared	0.677663	0.538600	0.636160	0.532405	0.542652	0.578635
Adj. R-squared	0.431171	0.185765	0.357930	0.174833	0.192915	0.256414
F-statistic	2.749224	1.526493	2.286450	1.488944	1.551599	1.795773
Log likelihood	93.37100	64.04812	82.75482	3.370576	74.70838	29.24922
Akaike AIC	-5.12071	-3.228911	-4.435795	0.685769	-3.91667	-0.983821
Schwarz SC	-4.473103	-2.581304	-3.788188	1.333376	-3.269063	-0.336214

Source: As for table 5A and 5B (figures in square brackets indicate t-values)