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Allocative Efficiency of the Indian Banking System in the Post-Reform Period: A State Level Analysis

Biswa Swarup Misra*

This paper examines whether allocative efficiency of the Indian Banking system has improved after the introduction of financial sector reforms in the early 1990s. Allocative efficiency has been studied for twenty three States of India. To get a comparative perspective, allocative efficiency has been estimated for two periods 1981-1992 and 1993-2001; broadly corresponding to the pre financial sector reforms and the post reforms periods, respectively. The analysis carried under panel cointegration framework reveals that overall allocative efficiency of the banking system has almost doubled in the post reform period. This goes to suggest the success of reforms in improving allocative efficiency of the banking system in India. Allocative efficiency at the State and sectoral level has also been estimated to get a deeper insight. While allocative efficiency of Banks' funds deployed in the services sector has improved that in the agriculture and industry has deteriorated in the post reform period for the majority of the States. The study finds improvement in the overall allocative efficiency in the post reform period for the majority of the States. Further, the improved allocative efficiency is more marked for the services sector than for industry across the States.

JEL Classification: C230, D610, R110

Key Words: Allocative Efficiency, Panel Cointegration and Panel FMOLS.

Introduction

Enduring growth, in the context of a developing economy like India invariably requires that the economy be put to a trajectory of higher savings and ensuring, further, that the realised savings are chanelised into productive investment. In this scheme of growth, the banking system has a dual role to play. The banking system acts both as a mobiliser of savings as well as an allocator of credit for production and investment. Effectiveness of the banking sector's contribution to the economic

* The author is Research Officer in the Department of Economic Analysis and Policy, Reserve Bank of India. He deeply acknowledges the inspirations of Dr. Narendra Jadhav. The views expressed in the paper are solely of the author and not of the institution to which he belongs.

growth and development is broadly determined by its efficiency in the allocation of the mobilised savings amongst competing projects.

Financial sector reforms were initiated in India in 1992-93 to promote a diversified, efficient and competitive financial system with the prime objective of improving the allocative efficiency of available resources. Banking sector being the dominant segment in India's financial system, a number of measures specific to the banking system were initiated to improve its allocative efficiency. Freedom to price their products along commercial considerations, relaxation in various balance sheet restrictions in the form of statutory pre-emptions, exposing the banking sector to an increased competition by allowing entry of new private sector banks and the introduction of prudential norms relating to income recognition, asset classification and capital adequacy were some of the ingredients of the banking sector reforms. Improved allocative efficiency was sought to be achieved through operational flexibility, improved financial viability and institutional strengthening.

The early initiatives in the banking reforms were geared towards removing the functional and operational constraints impinging upon bank operations, and subsequently, providing them with greater operational autonomy to take decision based on commercial considerations. With gradual relaxation of administered controls, banks and financial institutions were expected to evolve as truly commercial entities. More importantly, the operation of banks under free interplay of market forces in a deregulated atmosphere was expected to lead to increased allocative efficiency of scarce resources among competing sources of demand. Banking sector reforms have been in vogue for more than a decade in India. In this context, it would be appropriate to study whether the various reform measures have helped in improving the allocative efficiency of the banking system.

This study seeks to enquire whether the financial sector reforms in general, and banking sector reforms in particular had any beneficial impact on the allocative efficiency of the banking system. To get a comparative perspective, the allocative efficiency of the banking

system in the post banking sector reforms period has been compared and contrasted with that of the pre-reform period. Allocative efficiency is measured for the twenty-three States of India, individually and as well for all the States taken together. In addition to the scenario at the aggregate level, the allocative efficiency in the sectoral context has also been studied to get a deeper insight. The rest of the study is schematised as follows. Section I discusses the manner in which allocative efficiency has been construed in this study. Section II reviews the literature on allocative efficiency. Some of the stylized facts regarding the credit deployment pattern are discussed in Section III. The data and the empirical framework have been discussed in Section IV. The econometric findings are discussed in Section V. Finally, Section VI presents some concluding observations.

Section I

Interpreting Allocative Efficiency

Efficiency of a financial system is generally described through four broad nomenclatures *i.e.*, information arbitrage efficiency, fundamental valuation efficiency, full insurance efficiency and functional efficiency. The ensuing discussion in this paper would centre around the concepts of functional or allocative efficiency. Allocative efficiency can be judged either directly by monitoring some proxy of allocative efficiency or indirectly by estimating the contribution of a financial variable to economic growth. As far as direct measures are concerned, the interest rate structure, cost of intermediation and net interest margin (RBI, 2002a) as measures of bank efficiency are the oftenly-used criterions to evaluate the allocative efficiency of the banking system.

Allocative efficiency, however, can also be inferred indirectly by studying whether a bank's resources are allocated to most productive uses or not. Most productive use, in turn, can be defined in terms of the economic rate of return (ERR) of a project financed by the banking system. Allocative efficiency would mean that projects with very high ERR are being financed by the banks. It would imply that the funds

of the banking system are so deployed as to maximise the rate of return (ERR) of the projects financed by them. The ERR of individual bank financed projects, however, is difficult to quantify in practice. Akin to the interpretation of allocative efficiency of a bank's resources in terms of the ERR for individual projects, one can conceptualise the allocative efficiency of the entire banking system. In an aggregated sense, allocative efficiency would imply that maximum output is obtained from the deployment of banking system's resources. The concept of 'maximum output', however, is rather vague. As such, studying changes in allocative efficiency reflected in changes in output from a given pool of financial resources under two different time periods or circumstances is more comprehendible than the concept of allocative efficiency *per se*.

Allocative efficiency of an individual bank involves some sort of constrained optimisation. When studied in the cross section dimension, efficiency measurement generally involves use of nonparametric frontier methodology (English, Grosskopf *et al.*, 1993). In the panel context, however, the frontier approach does not capture the panel nature of the data and treats each observation as a separate unit. So it is like a pooled regression, unlike random/ fixed effects models. There are recent developments to overcome this problem, but it is still in a nascent stage. Consequently in a panel context, following RBI (2002a) allocative efficiency has been approximated by the elasticity of output with respect to credit in this study

Section II

Review of Literature

There has been a revival of finance and economic development linkage by the endogenous growth theory over the past decade. In the endogenous growth theory framework, bank finance has a scope to influence economic growth by either increasing the productivity of capital, lowering the intermediation cost, or augmenting the savings rate. The role of financial institutions is to collect and

analyse information so as to channel investible funds into investment activities that yield the highest returns [Greenwood and Jovanovic (1990)]. Though in a pure neo-classical framework, the financial system is irrelevant to economic growth, in practice, an efficient financial system can simultaneously lower the cost of external borrowing, raise the return to savers, and ensure that savings are allocated in priority to projects that promise the highest returns; all of which have the potential for improving growth rates (RBI, 2001a).

Commercial banks are the main conduit for resource allocation in a bank dominated financial system like India. Commercial banks generally provide the working capital needs of business. There is no strict boundary of division, however, in the usage of the funds; once disbursed by financial institutions. Once allocated, a part of the bank funds may very well be put towards building up fixed capital. This is because, a business enterprise would be encouraged to undertake fixed capital formation, once it is assured of working capital needs. Though in India there have been institutions created specifically to meet the long term investment needs of business enterprise, the pervasive character of the scheduled commercial banks had a greater role to play in reaching to a wider mass of people through its vast branch-banking network.

Pattrick (1966) provides a reference framework to study financial development by enunciating the 'demand-following approach' and the 'supply-leading approach' to financial development. Demand following is defined as a situation where financial development is an offshoot of the developments in the real sector. In the case of supply leading, financial development precedes and stimulates the process of economic growth; the supply of financial services and instruments create the demand for them. Patrick suggested that in the early stages of economic development, a supply-leading relation is more likely since a direct stimulus is needed to mobilise savings to finance investment for growth. At a later stage, when the financial sector is more developed, the demand-

following relation will be more prevalent. Empirical studies such as Gupta (1984), Jung (1986) and St. Hill (1992) are broadly suggestive of the pattern of financial development envisaged by Patrick (1966). However, such a theoretical dichotomy between 'demand following' and 'supply leading' is difficult to defend in the context of continuous interaction between the real and the financial sectors in practice.

Regarding the impact of bank finance on growth, a number of empirical studies drive home the positive impact of bank credit on output. Employing GMM panel estimators on a panel data set of 74 countries and a cross sectional instrumental variable estimator for 71 countries, Levine *et al* (2000) find that the exogenous component of financial intermediary development is positively associated with economic growth. Further, empirical studies by King and Levine (1993), Gregorio and Guidotti (1995) strongly borne out the positive effect of financial development on the long run growth of real per capita GDP. In the tradition of disentangling the impact of bank credit on growth, Reserve Bank of India (2002a) explored the relative impact of finance in inducing output growth using panel regression techniques. Estimates of elasticity of output with respect to credit improved from 0.30 during the period 1981-1991 to 0.35 during 1992-2001 indicating as improvement in the allocative efficiency of the banking system at the all India level (RBI 2002a). Sector-wise credit elasticities of output also indicate as improvement in the allocative efficiency for most of the sectors in the post reform period compared to the 1980s. However, no attempt has been made to study allocative efficiency at the State level and across the sectors. The present study seeks to fill this gap.

Section III

Credit and Output in the Spatial Dimension: Some Stylised Facts

The relative growth rates in credit and output in the pre and post-reforms periods can act as pointers to allocative efficiency. Aggregate credit has grown at a similar pace both in the pre reform and the post

Table 1: Growth of Output and Credit

(Per cent)

VARIABLE	1981-1992		1993-2001		1981-2001	
	Output	Credit	Output	Credit	Output	Credit
NSDP*	2.7	12.9	4.1	12.9	3.1	13.2
Agriculture	1.6	11.1	0.7	9.6	1.5	9.1
Industries	3.6	15.1	5.6	11.5	4.2	14.2
Services	4.0	11.2	6.0	15.3	4.6	13.3

* Net State Domestic Product

Source : Central Statistical Organisation and Reserve Bank of India

reform period, aggregate output, however, grew at a distinctly higher rate in the post reform phase. This indicates that at the aggregate level, there could be some improvement in the allocative efficiency. However, one finds a mixed picture at the sectoral level. While both output and credit growth has decelerated for the agricultural sector, that for services sector has accelerated in the post reform phase as compared to the pre reform phase. For industry, however, higher growth in output is witnessed in spite of deceleration in credit growth in the reform period.

Focusing only on growth rates of output and credit to comment on the allocative efficiency may be quite misleading, if the share of different sectors in aggregate credit and output has not remained the same. In fact, the share in credit and output has increased for both industry and services sector and has declined for the agriculture sector in the post reform period (Table 2). Thus, a much deeper

Table 2: Share in Output and Credit

(Per cent)

Sector	Average Share in the pre-banking sector reform period		Average Share in the post banking sector reform period	
	Output	Credit	Output	Credit
Agriculture	37	15.7	29	10
Industry	23	43.5	25.5	48
Services	40	40.8	45.5	42

Source : Central Statistical Organisation and Reserve Bank of India.

analysis is required to comment on the allocative efficiency in different sectors in the post reform phase.

At the State level, all the States under study can be broadly classified into four categories based on their shares in aggregate credit and output. States with increased share in output and credit in the post reform phase as compared to the pre reform period are the 'Group A' States. States with increased share in output but reduced share in credit are the 'Group B' States. States with increased share in credit and reduced share in output are 'Group C' status, and States with decline in their share in output and credit belong to the 'Group D' category. As can be seen from Table 3, the majority of the States (Thirteen) belong to Group D, which have suffered a decline in their share in aggregate output and credit. In total, share of credit in the aggregate credit has gone down for 16 States and has improved for 7 States in the post reform phase.

Considerable inequality is thus, seen among the States in terms of their share in overall credit. In such a scenario, it becomes

Table 3 : Changing Share of Different States in Output and Credit: A Comparison of Pre-Reform and Post-Reform Period

States with increased share in output and credit (Group A)	States with increased share in output but reduced share in credit (Group B)	States with increased share in credit and reduced share in output (Group C)	States with decline in their share in output and credit (Group D)
Andhra Pradesh, Delhi, Tamil Nadu, Maharastra, Karnataka and Gujarat	Arunachal Pradesh, Rajasthan and West Bengal	Kerala	Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, Pondicherry, Manipur, Madhya Pradesh, Punjab, Orissa, Uttar Pradesh, Tripura, Meghalaya and Haryana

Source : Central Statistical Organisation and Reserve Bank of India.

interesting to enquire, whether, States receiving an increasing share of the credit resource have been able to make the most of it. In other words, whether, rising credit shares are also accompanied with improved allocative efficiency. Further, if allocative efficiency of credit has improved even for States that have undergone a decline in their share of credit, it would have well served the purpose of reforms in the banking sector. Hence, it would be useful to decipher, if any pattern is emerging at the State level, when allocative efficiency of the banking system is seen in conjunction with their credit shares.

Apart from differences in their shares in output and credit, States have also exhibited a varied pattern in their growth of output and credit in the post reform period. Based on their growth in aggregate credit and output, there can be four categories of States. States with increased share in output and credit in the post reform phase as compared to the pre reform period are the 'Group E' States. States with higher growth in output but lower growth in credit belong to 'Group F'. 'Group G' States are those with higher growth in credit and lower growth in output and States with reduced growth both in output and credit belong to the 'Group H' category.

Table 4: Growth in Output and Credit of Different States: A Comparison of Pre – Reform and Post - Reform Period

States with higher growth in output and credit (Group E)	States with higher growth output but lower growth in credit (Group F)	States with higher growth in credit and lower growth in output (Group G)	States with lower growth in output and credit (Group H)
Delhi, Karnataka, Kerala Maharastra, and Rajasthan	Andhra Pradesh, Gujarat, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Manipur, Meghalaya Pondicherry, Tamil Nadu, Tripura and West Bengal	Punjab and Haryana	Arunachal Pradesh, Assam, Bihar, Orissa and Uttar Pradesh

Source : Central Statistical Organisation and Reserve Bank of India.

The differential growth pattern in credit and output can act as a guide to comment on allocative efficiency across States. Group F States that have shown an increased growth in output along with low credit growth in the post reform period are likely to exhibit higher allocative efficiency. On the other hand, Group G States with lower output and higher credit growth are clear candidates where allocative efficiency would be deteriorating.

However, it is tricky to judge about the allocative efficiency for States belonging to the Group E and group H, that have experienced either increased or reduced growth both in credit and output. For Group E States, that have witnessed higher growth both in credit and output, allocative efficiency would be guided by the relative growth of output *vis-a-vis* that of credit. Similarly, for Group H States that have experienced a lower growth of both credit and output in the post reform phase, allocative efficiency would depend on the relative decline in one *vis-a-vis* the other.

The indications for allocative efficiency obtained from the above informal analysis, however, need to be corroborated with more rigorous analysis to arrive at robust inferences. The empirical framework to estimate the allocative efficiency is discussed in the next section.

Section IV

Data and Empirical Methodology

The study examines the allocative efficiency of the banking system for 23 States of India. Allocative efficiency has been estimated separately for the two periods 1981-1992 (first period) and 1993-2001(second period). The periods have been so chosen as to represent the pre banking sector reforms and the post banking sector reforms scenarios, respectively. The credit output dynamics has been studied for three broad sectors of each State *viz*, agriculture, industry and services. While measuring output; the following classification has been used. Agriculture includes agriculture, forestry and fishing

and logging. Industry includes mining, quarrying and manufacturing (registered and non-registered) and services include electricity, gas and water supply, transport, storage and communication, trade, hotels and restaurants, banking and insurance, real estate, ownership of dwellings and business services, public administration and other services. Income originating from the States rather than income accruing to State concept has been used to measure output. The data on output has been taken from the information supplied by the various States to the Central Statistical Organisation. SDP data at the 1993-94 base has been used in the study. The data on credit refers to the outstanding credit to different sectors from all scheduled commercial banks in a region. The data for credit has been taken from the 'Basic Statistical Returns' published by the Reserve Bank of India.

The output variable is represented by log of per capita net State Domestic Product (LPNSDP) and the credit variable by the log of per capita credit for the State (LPTCAS). Though certain new regions have been carved out from the existing ones in the year 2000, for analytical purposes, necessary adjustments have been made to make the output and credit figures for the year 2001 comparable to that for the previous years. The choice of the regions and the time period have been completely motivated by the availability and consistency of the data. However, with inclusion of regions having share of less than one percent and as well having more than ten percent in the combined NSDP for all the 25 regions, heterogeneity that prevails across the regions in India has been captured considerably.

Empirical Methodology

To estimate the credit elasticities of output, we have twelve data points for the pre reform and nine data points in the post reform period. Use of time series estimation techniques, however, is precluded given the small number of observations for estimation. However, taking advantage of the panel nature of the data, one can use panel data techniques. With panel data techniques, information

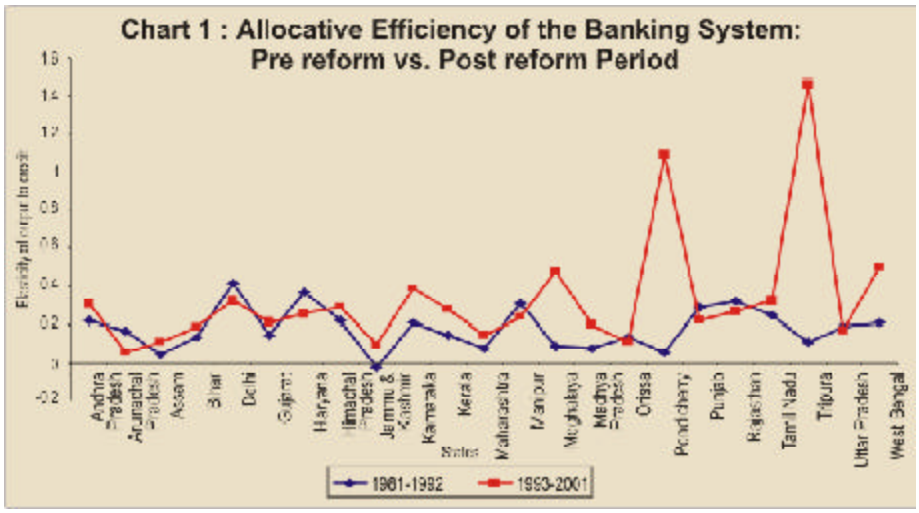
from the time-series dimension is combined with that obtained from the cross-sectional dimension, in the hope that inference about the existence of unit roots and cointegration can be made more straightforward and precise.

To ascertain the appropriate estimation technique, the variables have been first examined for stationarity in a panel context. If the variables are found to contain a unit root, the variables are then examined for possible cointegration. In the event cointegration between the variables, Fully Modified OLS (FMOLS) estimation technique is used to obtain coefficient estimates. Specifically, the panel unit root tests developed by Levin, Lin and Chu and Im, Pesaran and Shin have been employed. Pedroni's method is used to test for panel cointegration. Fully modified OLS estimation technique given by Pedroni is used to derive the elasticities. The details of the empirical methodology are given in the Annex 6.

Section V

Empirical Results

The results of the panel unit root tests for each of our variables are shown in Annex 3. In no case, can we reject the null hypothesis that every country has a unit root for the series in log levels. Once ascertained that both the variables are I (1), we turn to the question of possible cointegration between log of per capita SDP and log of per capita credit. In the absence of cointegration, we can first differentiate the data and then work with these transformed variables. However, in the presence of cointegration, the first differences do not capture the long run relationships in the data and the cointegration relationship must be taken into account. Annex 4 depicts the evidence on the cointegration property between per-capita SDP and per-capita credit for the Indian States. The panel cointegration tests suggested by Pedroni (1999) have been applied. In general, the Pedroni (1999) tests turn out to be in favour of a cointegrating relation between the variables that are non stationary. The agriculture sector has not been



studied for cointegration as the output variable for agriculture is stationary and the credit variable is non stationary. [2]

Efficient FMOLS estimation technique is used to obtain the estimate of elasticity of output with respect to credit for each sub-period. The results are given in Annex 5. The changing allocative efficiency over time and across States can be seen from Chart 1. The results broadly indicate an improvement in the allocative efficiency for the majority of the States.[3] For instance, for fifteen States, there was an improvement in allocative efficiency with respect to the State Domestic Product. It may be noted that eight out of these fifteen States had undergone a decline in their share in aggregate credit in the post reform period.

As indicated by the analysis of growth in terms of credit and output, the allocative efficiency of banks' funds has improved for all States that had higher output and lower credit growth in the post reform phase.[4] For all States taken together, allocative efficiency has improved from 0.18 to 0.34 as indicated by the pooled estimates. An overview of the results in terms of States and sectors that have witnessed an improvement in allocative efficiency of bank funds is given in Table 5. At the sectoral level, an improvement in allocative efficiency of bank funds in the services sector is witnessed for 18 States and in the industrial sector for 12 States (Table 5).

Table 5: Allocative Efficiency Across Sectors and States in the Post reform period

State	Sectors		
	Industry	Services	Overall[5]
ANDHRA PRADESH	Ö	Ö	Ö
ARUNACHAL PRADESH		Ö	
ASSAM	Ö		Ö
BIHAR		Ö	Ö
DELHI			
GUJARAT		Ö	Ö
HARYANA		Ö	
HIMACHAL PRADESH	Ö	Ö	Ö
JAMMU & KASHMIR		Ö	Ö
KARNATAKA	Ö	Ö	Ö
KERALA	Ö	Ö	Ö
MADHYA PRADESH	Ö		Ö
MAHARASHTRA	Ö	Ö	Ö
MANIPUR			
MEGHALAYA		Ö	Ö
ORISSA		Ö	
PONDICHERRY	Ö	Ö	Ö
PUNJAB	Ö	Ö	
RAJASTHAN	Ö		
TAMIL NADU	Ö	Ö	Ö
TRIPURA		Ö	Ö
UTTAR PRADESH		Ö	
WEST BENGAL	Ö	Ö	Ö

Note : Ö indicates improvement in allocative efficiency in the post reform phase as compared to the pre reform period. Blank cells indicate deterioration in allocative efficiency in the post reform period.

Section VI

Conclusion

One of the main aims of financial sector reforms in the post 1990s was to improve the allocative efficiency of the financial system. The efficiency improvement of the banking system has a bearing on the overall efficiency of the Indian financial system as the banking sector has a dominant role to play in the entire financial edifice. This study attempted to enquire into the allocative efficiency of the Indian banking system on a wider canvass encompassing twenty three States and across the agriculture, industry and services sectors.

The finding of the study broadly corroborates that there has been an improvement in allocative efficiency for all States taken together as far as elasticity of total output to total credit is concerned. At the sectoral level, however, the picture is mixed. For the services sector there has been a distinct improvement in allocative efficiency of credit in the post reform period. The agriculture and industry sector, however, have witnessed a decline in the allocative efficiency of credit in the same period. At the State level, majority of the States witnessed an improvement in the overall allocative efficiency in the post reform period. The improved allocative efficiency is more marked for the services sector than for industry across the States.

Notes

1 Given that credit – output relations involve relatively short time series dimensions, and the well known low power of conventional unit root tests when applied to a single time series, there may be considerable potential for tests that can be employed in an environment where the time series may be of limited length, but very similar data may be available across a cross–section of countries, regions, firms, or industries.

2 Both fixed and random effects estimation of elasticity of output with respect to credit shows deterioration in allocative efficiency in the post reform period for the agriculture sector.

3 Allocative efficiency as defined by elasticity of SDP with respect to total credit. The individual and pooled FMOLS estimates are given in Annex-5.

4 Manipur is an exception

5 Overall refers to the State Domestic Product

References

Banerjee, A. (1999): "Panel Data Unit Root Tests and Cointegration: An Overview", *Oxford Bulletin of Economics and Statistics, Special Issue,* Vol.61, pp.607-629.

Engle, R. F. and Granger, C. W. J. (1987): " Cointegration and Error Correction: Representation, Estimation, and Testing", *Econometrica,* Vol.55 (2), pp. 251-276.

English, M, Grosskopf, S, Hayes and K, Yaisawarng, S. (1993): "Output Allocative and Technical Efficiency of Banks", Journal *of Banking & Finance,* Vol. 17, No.2-3, pp. 349-366.

Gregorio, J. D. and Guidotti, P. E. (1995): "Financial Development and Economic Growth", *World Developmen*t, Vol.23, No.3, pp.433-448.

Gupta, K.L. (1984): "Finance and Economic Growth in Developing Countries', *Croom Helm*, London.

Hadri, K. (2000): "Testing for Stationarity in Heterogeneous Panel Data", *Econometrics Journal,* Vol.3, pp.148-161.

Im, K. S., Pesaran, M. H. and Shin, S. (1995): "Testing for Unit Roots in Heterogeneous Panels", Mimeo, *Department of Applied Economics, University of Cambridge.*

Im, K.S., Pesaran, M.H., and Y. Shin (1997): "Testing for Unit Roots in Heterogeneous panels", Mimeo, *Department of Applied Economics, University of Cambridge.*

Jung, W. S. (1986): "Financial Development and Economic Growth : International Evidence", *Economic Development and Cultural Change*, Vol. 34, No. 2, PP. 333-346

King, Robert G. and Levine Ross (1993): "Finance and Growth: Schumpeter Might Be Right.", *Quarterly Journal of Economics*, Vol.108 (3), pp. 717-738.

King, R. and Levine R. (1993): "Financial Intermediation and Economic Development", in C. Mayer and X. Vives (eds), *Capital Markets and Financial Intermediation, Cambridge,* Cambridge University Press.

Kao, Chiwa, McCoskey, Suzanne (1998): "A Residual-Based Test of the Null of Cointegration in Panel Data", *Econometric Reviews*, Vol. 17, pp. 57-84.

Levine, R., Loayza N. and Beck T. (2000): "Financial Intermediation and Growth: Causality and Causes", *Journal of Monetary Economics*, Vol.46, pp .31-77.

Levine, Ross (1996b): "Financial Development and Economic Growth: Views and Agenda", *Journal of Economic Literature,* Vol.35, pp.688-726.

Levin, Andrew and Chien-Fu Lin (1992): "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties", Discussion paper No. 92-93, *Department of Economics, University of California, San Diego.*

Levin, Andrew and Chien-Fu Lin (1993): "Unit Root Tests in Panel Data: New Results", Discussion paper No. 93-56, *Department of Economics, University of California, San Diego.*

Levin, A., Lin. C.-F. and C-S. Chu (2002): "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties". *Journal of Econometrics*, Vol.108, pp.1-24.

Nyblom, J. and A. Harvey (2000): "Tests of Common Stochastic Trends", *Econometric Theory*, Vol.16, pp. 176-199.

Nyblom, J. and T. Makelainen (1983): "Comparison of Tests for the Presence of Random Walk Components in a Simple Linear Model", *Journal of the American Statistical Association*, Vol. 78, pp.856-864.

Pedroni, Peter (1999): "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors", *Oxford Bulletin of Economics and Statistics*, Vol.61, Special Issue, pp.653-670.

Pedroni, Peter (2001): "Purchasing Power Parity Tests in Cointegrated Panels", *Review of Economics and Statistics*, Vol.83, pp. 727-731.

Partick, H.T. (1966): "Financial Development and Economic Growth in Underdeveloped Countries", *Economic Development and Cultural Change*, Vol.14, pp.174-189.

Reserve Bank of India (2001a): *Report on Currency and Finance*, 1999-2000.

Reserve Bank of India (2001b): *Annual Report*, 2000-01.

Reserve Bank of India (2002a): *Report on Currency and Finance*, 2000-01.

Ross (1996): "Financial Development and Economic Growth", *The World Bank, Washington*, D.C. Policy Research Working Paper, 1678.

St. Hill, R.L. (1992): "Stages of Banking and Economic Development", *Savings and Development*, Vol. 16, No. 1, pp. 65-94.

Annex 1: Growth of Sector-wise Output[1]

(Per cent)

State	Agriculture			Industry			Services			NSDP		
	1981-1992	1993-2001	1981-2001	1981-1992	1993-2001	1981-2001	1981-1992	1993-2001	1981-2001	1981-1992	1993-2001	1981-2001
ANDHRA PRADESH	0.1	1.5	0.7	6.1	6.2	6.3	6.0	5.8	5.4	3.6	4.5	3.8
ARUNACHAL PRADESH	5.1	-3.5	2.4	5.1	0.9	5.3	6.0	6.8	6.6	5.4	1.0	4.4
ASSAM	0.1	-0.3	-0.1	1.4	2.0	0.5	2.4	1.4	2.3	1.2	0.8	1.0
BIHAR	0.2	-0.4	-1.3	4.3	3.8	2.1	3.2	3.6	2.7	2.2	2.1	0.9
DELHI	-0.3	-10.8	-6.8	4.1	-0.3	2.7	3.4	5.9	4.5	3.5	4.1	3.8
GUJARAT	-2.8	-3.1	-0.2	4.8	4.3	5.9	5.0	6.8	5.5	2.4	3.7	4.0
HARYANA	2.1	-0.3	1.3	6.4	4.1	4.3	5.4	7.2	5.1	4.0	3.5	3.3
HIMACHAL PRADESH	0.3	-1.8	-0.2	5.4	7.2	6.5	5.0	5.1	4.1	3.0	3.6	3.1
JAMMU & KASHMIR	-2.6	1.2	-0.8	2.4	-2.9	0.2	1.1	3.7	2.2	-0.3	1.8	0.7
KARNATAKA	0.7	3.0	1.9	4.9	5.8	4.8	5.5	9.0	6.4	3.4	6.1	4.3
KERALA	1.2	0.4	1.8	1.9	4.1	4.3	2.8	6.8	4.8	2.0	4.3	3.7
MADHYA PRADESH	-0.4	-1.8	0.3	2.7	7.4	6.8	4.1	4.0	3.5	1.6	2.1	2.1
MAHARA-SHTRA	0.7	-0.9	1.7	3.9	4.4	4.3	5.0	5.9	6.2	3.6	4.2	4.6
MANIPUR	-0.4	1.9	0.2	4.0	8.1	3.0	4.1	5.3	4.2	2.2	4.9	2.7
MEGHALAYA	-1.6	2.7	-1.1	2.6	6.7	4.0	4.9	2.8	3.6	2.3	3.4	2.2
ORISSA	-0.8	-0.9	-1.4	5.1	-1.9	4.1	4.3	5.9	4.4	2.0	1.6	1.4
PONDI-CHERRY	-1.8	-2.7	-2.6	1.0	21.6	3.2	2.2	10.0	5.2	0.9	12.3	2.8
PUNJAB	3.1	0.2	1.9	5.1	4.9	5.0	2.5	4.9	2.8	3.3	2.8	2.9
RAJASTHAN	1.9	0.0	1.7	4.3	7.0	5.6	6.2	5.8	5.4	3.7	4.1	3.8
TAMIL NADU	2.6	0.8	2.7	3.2	4.4	4.1	5.1	8.2	6.2	3.9	5.3	4.7
TRIPURA	-0.1	0.4	-0.6	-1.2	12.3	4.2	6.2	5.0	5.9	2.6	4.4	3.1
UTTAR PRADESH	0.5	0.0	0.3	5.2	2.5	3.3	3.9	2.9	3.0	2.5	1.7	1.9
WEST BENGAL	3.2	2.1	2.9	1.3	4.4	2.6	2.7	8.3	4.6	2.4	5.5	3.5

[1] Compound annual growth rates.

Annex 2: Growth of Sector-wise Credit[2]

(Per cent)

State	Agriculture			Industry			Services			Total Credit		
	1981-1992	1993-2001	1981-2001	1981-1992	1993-2001	1981-2001	1981-1992	1993-2001	1981-2001	1981-1992	1993-2001	1981-2001
ANDHRA PRADESH	14.0	11.1	11.0	17.1	12.3	14.9	19.7	17.2	17.4	17.0	14.1	14.8
ARUNACHAL PRADESH	37.3	7.7	19.6	36.4	-7.2	11.1	23.8	20.3	18.5	32.3	5.7	15.2
ASSAM	15.3	-1.9	7.2	19.4	1.7	8.9	17.8	13.7	13.2	18.0	6.8	10.6
BIHAR	14.8	0.3	10.0	11.0	1.6	8.7	20.2	8.4	14.8	15.1	4.9	11.5
DELHI	-5.9	19.4	9.1	14.1	10.3	16.2	4.3	15.1	11.0	7.9	12.3	13.2
GUJARAT	14.3	6.7	11.1	15.1	15.4	14.0	15.3	16.0	15.6	15.0	14.5	14.0
HARYANA	11.4	8.5	7.6	12.8	15.8	12.4	13.2	13.3	12.1	12.4	13.5	11.0
HIMACHAL PRADESH	13.4	7.1	7.6	18.0	12.2	12.4	16.8	12.2	13.3	16.5	11.6	12.1
JAMMU & KASHMIR	13.0	8.6	7.3	16.6	4.8	8.9	16.1	17.9	14.8	15.9	14.2	12.6
KARNATAKA	16.1	12.2	12.1	14.8	15.1	14.0	17.2	19.5	16.0	15.9	16.3	14.3
KERALA	13.6	12.3	11.1	11.8	11.1	11.0	14.9	17.6	15.3	13.5	14.9	13.2
MADHYA PRADESH	17.1	10.2	12.1	18.7	14.6	14.6	19.2	10.7	15.0	18.5	12.1	14.1
MAHARA-SHTRA	12.0	12.8	10.6	14.1	16.6	15.5	13.1	17.6	15.4	13.4	16.9	15.1
MANIPUR	23.3	7.9	13.0	38.8	1.3	19.9	21.2	12.8	14.1	25.3	8.6	15.3
MEGHALAYA	27.2	-3.7	10.1	36.0	5.7	16.0	17.1	9.5	14.3	23.3	6.3	13.7
ORISSA	14.0	8.1	9.2	19.8	7.9	12.2	20.1	14.1	14.9	18.5	11.0	12.7
PONDI-CHERRY	7.8	7.5	6.9	15.4	7.1	12.2	16.2	15.1	15.8	14.0	10.6	12.5
PUNJAB	7.9	11.0	7.0	15.9	14.2	13.4	10.1	14.7	12.7	11.3	13.8	11.3
RAJASTHAN	14.2	12.3	11.1	12.9	12.7	13.0	14.6	16.1	14.1	13.8	13.9	12.9
TAMIL NADU	16.1	8.4	12.2	16.0	16.1	15.5	17.9	17.6	17.8	16.6	15.8	15.9
TRIPURA	20.4	1.7	10.1	26.9	-2.3	10.9	21.8	4.6	12.5	22.5	2.8	11.6
UTTAR PRADESH	13.6	9.0	10.8	13.8	8.5	11.3	16.7	11.3	13.2	14.8	9.8	11.9
WEST BENGAL	14.4	3.9	8.1	11.8	8.7	10.9	16.7	13.1	14.4	13.4	10.0	11.8

[2] Compound annual growth rates.

Annex 3 : Panel Unit Root Tests

	1981-1992				1993-2001			
Variable	**Levin-Lin rho -stat**	**Levin-Lin t-rho -stat**	**Levin-Lin ADF-stat**	**IPS ADF -stat**	**Levin-Lin rho -stat**	**Levin-Lin t-rho -stat**	**Levin-Lin ADF-stat**	**IPS ADF -stat**
LPAGRI	-7.80	-4.52	-2.58	-6.13	-6.67	-4.56	-3.73	-6.31
LPINDS	1.15	2.27	2.37	2.45	0.47	0.73	0.73	-0.42
LPSERV	2.45	3.36	3.53	4.54	2.49	3.46	3.25	2.85
LPNSDP	1.75	2.91	3.58	3.99	1.58	2.18	2.51	2.29
LPACS	0.82	0.68	1.33	1.46	1.67	2.82	2.63	2.36
LPICS	2.09	2.40	1.98	0.74	1.49	2.57	1.87	0.17
LPSCS	1.08	1.20	2.81	5.31	2.36	3.49	3.22	3.88
LPTCAS	1.64	1.73	2.58	2.20	2.47	3.53	3.33	2.54

Notes : a. The critical values are from Levin and Lin (1992).
b. IPS indicates the Im et al. (1997) test. The critical values are taken from Table 4.
c. Unit root tests include a constant and heterogeneous time trend in the data.

Annex 4 : Panel Cointegration Tests

	1981-1992			1993-2001		
Statistics	**LPINDS and LPICS**	**LPSERV and LPSCS**	**LPNSDP and LPTCAS**	**LPINDS and LPICS**	**LPSERV and LPSCS**	**LPNSDP and LPTCAS**
Panel *v*-statistics	4.52	2.49	2.97	1.02	2.80	1.79
Panel *rho*-statistics	-1.96	-1.71	-1.51	-0.39	-0.84	-0.80
Panel *pp*-statistics	-3.57	-2.96	-2.96	-3.83	-2.89	-3.65
Panel *adf*-statistics	-4.45	-3.47	-1.99	-2.03	-3.32	-2.48
Group *rho*-statistics	-0.34	0.21	0.0006	1.01	1.35	0.47
Group *pp*-statistics	-4.31	-3.02	-3.20	-6.66	-3.56	-6.44
Group *adf*-statistics	-5.75	-5.09	-3.75	-23.83	-15.36	-22.65

Notes : The critical values for the panel cointegration tests are base on Pedroni (2001a).

LPAGRI = Log of per capita agricultural output
LPINDS = Log of per capita industrial output
LPSERV = Log of per capita services sector output
LPNSDP = Log of per capita net State domestic product
LPACS = Log of per capita agricultural credit
LPICS = Log of per capita industrial credit
LPSCS = Log of per capita services sector credit
LPTCAS = Log of per capita total credit outstanding for all sectors of the State

Annex 5 : Individual and Pooled FMOLS Results

States	1981-1992	1993-2001	1981-1992	1993-2001	1981-1992	1993-2001
	LPNSDP	LPNSDP	LPINDS	LPINDS	LPSERV	LPSERV
ANDHRA PRADESH	0.22 (-12.95)	0.31 (-33.96)	0.41 (-10.60)	0.44 (-27.86)	0.32 (-13.61)	0.35 (-45.14)
ARUNACHAL PRADESH	0.17 (-42.90)	0.06 (-26.11)	0.15 (-31.56)	0.1 (-6.07)	0.34 (-19.96)	0.38 (-8.08)
ASSAM	0.05 (-78.06)	0.11 (-48.25)	-0.03 (-86.56)	0.25 (-11.31)	0.14 (-37.71)	0.09 (-52.65)
BIHAR	0.14 (-26.38)	0.19 (-8.86)	0.34 (-12.21)	0.05 (-6.08)	0.17 (-153.24)	0.37 (-8.82)
DELHI	0.42 (-10.74)	0.33 (-11.09)	0.32 (-32.89)	-0.09 (-16.46)	0.55 (-2.82)	0.36 (-9.69)
GUJARAT	0.15 (-29.75)	0.21 (-13.17)	0.28 (-15.23)	0.27 (-24.29)	0.34 (-27.64)	0.47 (-14.50)
HARYANA	0.37 (-11.96)	0.26 (-85.73)	0.52 (-9.53)	0.25 (-235.33)	0.43 (-8.25)	0.52 (-31.67)
HIMACHAL PRADESH	0.22 (-12.84)	0.29 (-41.42)	0.03 (-14.24)	0.47 (-7.34)	0.34 (-11.42)	0.46 (-18.74)
JAMMU & KASHMIR	-0.02 (-38.75)	0.1 (-61.07)	-0.19 (-13.13)	-0.24 (-13.86)	0.08 (-67.00)	0.2 (-51.85)
KARNATAKA	0.21 (-25.53)	0.39 (-13.58)	0.02 (-43.88)	0.4 (-12.76)	0.34 (-24.92)	0.47 (-15.15)
KERALA	0.15 (-15.67)	0.28 (-49.23)	0.09 (-13.33)	0.3 (-36.07)	0.2 (-31.35)	0.4 (-25.86)
MAHARASHTRA	0.08 (-33.23)	0.15 (-36.83)	-0.05 (-47.65)	0.29 (-27.18)	0.23 (-47.62)	0.38 (-18.57)
MANIPUR	0.31 (-14.19)	0.24 (-74.81)	0.03 (-9.61)	0.25 (-55.47)	0.4 (-5.83)	0.35 (-24.06)
MEGHALAYA	0.09 (-97.31)	0.48 (-2.92)	-0.01 (-129.84)	0.02 (-1.38)	0.2 (-47.02)	0.44 (-7.77)
MADHYA PRADESH	0.08 (-22.14)	0.2 (-6.10)	-0.06 (-75.61)	0.14 (-5.11)	0.29 (-10.05)	0.24 (-9.58)
ORISSA	0.14 (-55.82)	0.11 (-58.34)	0 (-16.08)	-0.59 (-9.70)	0.25 (-76.56)	0.43 (-60.82)
PONDICHERRY	0.06 (-57.65)	1.09 -0.48	-0.12 (-13.49)	2.19 -1.18	0.14 (-133.73)	0.66 (-8.45)
PUNJAB	0.29 (-11.00)	0.22 (-86.15)	0.16 (-7.50)	0.34 (-17.70)	0.27 (-18.51)	0.37 (-16.08)
RAJASTHAN	0.32 (-12.24)	0.27 (-11.18)	0.14 (-6.93)	0.53 (-13.45)	0.46 (-8.75)	0.37 (-16.27)
TAMILNADU	0.25 (52.30)	0.33 (-63.08)	0.16 (-23.21)	0.24 (-28.70)	0.32 (-65.09)	0.5 (-15.10)
TRIPURA	0.11 (-22.23)	1.46 -1.91	0 (-39.83)	-2.31 (-3.05)	0.3 (-19.08)	0.97 (-0.64)
UTTAR PRADESH	0.19 (-63.23)	0.17 (-38.75)	0.05 (-51.47)	0.29 (-11.36)	0.27 (-30.85)	0.28 (-64.79)
WEST BENGAL	0.21 (-30.22)	0.5 (-29.80)	0.21 (-16.57)	0.49 (-29.83)	0.17 (-70.59)	0.63 (-9.82)
POOLED	**0.18 (-162.03)**	**0.34 (-166.41)**	**0.03 (-156.24)**	**0.18 (-124.94)**	**0.28 (-194.26)**	**0.42 (-111.37)**

Note : Figures are estimated elasticities of output with respect to credit of the respective sectors.
Figures in parenthesis indicate t-values

Annex 6

Panel Unit Root, Panel Cointegration and Fully Modified OLS Estimation

Panel unit root Tests

There are several techniques, which can be used to test for a unit root in panel data. Specifically, we are interested to test for non-stationarity against the alternative that the variable is trend stationary.

Levin, Lin and Chu (LLC) Test

One of the first unit root tests to be developed for panel data is that of Levin and Lin, as originally circulated in working paper form in 1992 and 1993. Their work was finally published, with Chu as a coauthor, in 2002. Their test is based on analysis of the equation:

$$\Delta y_{i,t} = \alpha_i + \delta_i t + \theta_t + \rho_i y_{i,t-1} + \varepsilon_{i,t}\ ,$$
$$i = 1,2,..N, t = 1,2,...T.$$

This model allows for two-way fixed effects (α and θ) and unit-specific time trends. The unit-specific fixed effects are an important source of heterogeneity, since the coefficient of the lagged dependent variable is restricted to be homogeneous across all units of the panel. The test involves the null hypothesis H_0: $\rho_i = 0$ for all i against the alternative H_A: $\rho_i = \rho < 0$ for all i with auxiliary assumptions under the null also being required about the coefficients relating to the deterministic components. Like most of the unit root tests in the literature, LLC assume that the individual processes are cross-sectionally independent. Given this assumption, they derive conditions and correction factors under which the pooled OLS estimate will have a standard normal distribution under the null hypothesis. Their work focuses on the asymptotic distributions of this pooled panel estimate of ρ under different assumptions on the existence of fixed effects and homogeneous time trends. The LLC test may be viewed as a pooled Dickey-Fuller (or ADF) test, potentially with differing lag lengths across the units of the panel.

The Im-Pesaran-Shin Test

The Im-Pesaran-Shin (IPS, 1997) test extends the LLC framework to allow for heterogeneity in the value of ρ_i under the alternative hypothesis.

Given the same equation: $$\Delta y_{i,t} = \alpha_i + \delta_i t + \theta_t + \rho_i y_{i,t-1} + \varepsilon_{i,t}\ ,$$
$$i = 1,2,..N, t = 1,2,...T.$$

The null and alternative hypotheses are defined as: $H_0 : \rho_i = 0 \forall i$

and $H_A : \rho_i < 0, i = 1,2,..., N_1; \rho_i = 0, i = N_1 + 1, N_1 + 2,...N$

Thus under the null hypothesis, all series in the panel are nonstationary processes; under the alternative, a fraction of the series in the panel are assumed to be stationary. This is in contrast to the LLC test, which presumes that all series are stationary under the alternative hypothesis. The errors are assumed to be serially autocorrelated, with different serial correlation properties and differing variances across units. IPS propose the use of a group-mean Lagrange multiplier statistic to test the null hypothesis. The ADF regressions are computed for each unit, and a standardized statistic computed as the average of the LM tests for each equation. Adjustment factors (available in their paper) are used to derive a test statistic that is distributed standard Normal under the null hypothesis.

IPS also propose the use of a group-mean *t*-bar statistic, where the *t* statistics from each ADF test are averaged across the panel; again, adjustment factors are needed to translate the distribution of *t*-bar into a standard Normal variate under the null hypothesis. IPS demonstrates that their test has better finite sample performance than that of LLC. The test is based on the average of the augmented Dickey-Fuller (ADF) test statistics calculated independently for each member of the panel, with appropriate lags to adjust for auto-correlation. The adjusted test statistics, [adjusted using the tables in Im, Pesaran, and Shin (1995)] are distributed as N(0,1) under the

null of a unit root and large negative values lead to the rejection of a unit root in favor of stationarity.

Panel Cointegration Tests and Efficient Estimation

Cointegration analysis is carried out using a panel econometric approach. Since the time series dimension is enhanced by the cross section, the analysis relies on a broader information set. Hence, panel tests have greater power than individual tests, and more reliable findings can be obtained.

We use Pedroni's (1995, 1997) panel cointegration technique, which allows for heterogeneous cointegrating vectors. The panel cointegration tests suggested by Pedroni (1999) extend the residual based Engle and Granger (1987) cointegration strategy. First, the cointegration equation is estimated separately for each panel member. Second, the residuals are examined with respect to the unit root feature. If the null of no-cointegration is rejected, the long run equilibrium exists, but the cointegration vector may be different for each cross section. Also, deterministic components are allowed to be individual specific. To test for cointegration, the residuals are pooled either along the within or the between dimension of the panel, giving rise to the panel and group mean statistics (Pedroni, 1999). In the former, the statistics are constructed by summing both numerator and denominator terms over the individuals separately; while in the latter, the numerator is divided by the denominator prior to the summation. Consequently, in the case of the panel statistics the autoregressive parameter is restricted to be the same for all cross sections. If the null is rejected, the variables in question are cointegrated for all panel members. In the group statistics, the autoregressive parameter is allowed to vary over the cross section, as the statistics amounts to the average of individual statistics. If the null is rejected, cointegration holds at least for one individual. Therefore, group tests offer an additional source of heterogeneity among the panel members.

Both panel and group statistics are based on augmented Dickey Fuller (ADF) and Phillips- Perron (PP) method. Pedroni (1999) suggests 4 panel and 3 group statistics. Under appropriate

standardization, each statistic is distributed as standard normal, when both the cross section and the time series dimension become large.

The asymptotic distributions can be stated in the form

$$Z = \frac{Z^* - m\sqrt{N}}{\sqrt{v}} \qquad (1)$$

where Z* is the panel or group statistic, respectively, N the cross section dimension **m** and **n** and arise from of the moments of the underlying Brownian motion functionals. They depend on the number of regressors and whether or not constants or trends are included in the co-integration regressions. Estimates for **m** and **n** are based on stochastic simulations and are reported in Pedroni (1999). Thus, to test the null of no co-integration, one simply computes the value of the statistic so that it is in the form of (1) above and compares these to the appropriate tails of the normal distribution. Under the alternative hypothesis, the panel variance statistic diverges to positive infinity, and consequently the right tail of the normal distribution is used to reject the null hypothesis. Consequently, for the panel variance statistic, large positive values imply that the null of no co-integration is rejected. For each of the other six test statistics, these diverge to negative infinity under the alternative hypothesis, and consequently the left tail of the normal distribution is used to reject the null hypothesis. Thus, for any of these latter tests, large negative values imply that the null of no co-integration is rejected. The intuition behind the test is that using the average of the overall test statistic allows more ease in interpretation: rejection of the null hypothesis means that enough of the individual cross sections have statistics 'far away' from the means predicted by theory were they to be generated under the null.

Panel FMOLS

In the event the variables are co-integrated, to get appropriate estimates of the co-integration relationship, efficient estimation techniques are employed. The appropriate estimation method is so designed that the problems arising from the endogeneity of the regressors and serial correlation in the error term are avoided.

Due to the corrections, the estimators are asymptotically unbiased. Especially, fully modified OLS (FMOLS) is applied. In the model

$$y_{it} = a_i + b_i x_{it} + u_{it}$$
$$x_{it} = x_{it-1} + e_{it}, \quad v_{it} = (u_{it}, e_{it})' \tag{2}$$

the asymptotic distribution of the OLS estimator depends on the long run covariance matrix of the residual process w. This matrix is given by

$$\Omega_i = \lim_{T\to\infty} \frac{1}{T} E\left(\sum_{t=1}^{T} v_{it}\right)\left(\sum_{t=1}^{T} v_{it}\right) = \Sigma_i + \Gamma_i + \Gamma_i' = \begin{pmatrix} v_{u,i} & v_{ue,i} \\ v_{ue,i} & v_{e,i} \end{pmatrix} \tag{3}$$

for the *i*-th panel member, where

$$\Sigma_i = \lim_{T\to\infty} \frac{1}{T} \sum_{t=1}^{T} E\left(v_{it} v_{it}'\right) = \begin{pmatrix} s_{u,i}^2 & s_{ue,i} \\ s_{ue,i} & s_{e,i}^2 \end{pmatrix}$$

$$\Gamma_i = \lim_{T\to\infty} \frac{1}{T} \sum_{k=1}^{T-1} \sum_{t=k+1}^{T} E\left(w_{it} w_{it-k}'\right) = \begin{pmatrix} g_{u,i} & g_{ue,i} \\ g_{ue,i} & g_{e,i} \end{pmatrix} \tag{4}$$

denote the matrices of contemporaneous correlation coefficients and the auto-covariance, respectively, where the latter are weighted according to the Newey and West (1994) proposal. For convenience, the matrix

$$q_i = \begin{pmatrix} q_{u,i} & q_{ue,i} \\ q_{eu,i} & q_{e,i} \end{pmatrix} = \Sigma_i + \Gamma_i = \sum_{j=0}^{\infty} E\left(w_{ij} w_{i0}\right)' \tag{5}$$

is defined. The endogeneity correction is achieved by the transformation

$$y_{it}^* = y_{it} - \hat{v}_{ue,i}\, \hat{v}_{e,i}^{-1}\, \Delta x_{it} \tag{6}$$

and the fully modified estimator is

$$\hat{b}_i^* = \left(X_i' X_i\right)^{-1} \left(X_i' y_i^* - T \hat{q}_{eu}^*\right) \tag{7}$$

where, $\hat{q}_{eu}^* = \hat{q}_{eu} - \hat{q}_e\, \hat{v}_{ei}^{-1}\, \hat{v}_{eu,i}$

provides the autocorelation correction, The estimates needed for the transformations are based on OLS residuals obtained in a preliminary step. The panel FMOLS estimator is just the average of the individuals parameters.