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REVIEW

Structural changes, market growth and productivity gains of the US real estate investment trusts in the 1990s

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Abstract The 1990s were tumultuous times for the US Real Estate Investment Trusts (REITs) industry. Significant structural changes occurred during the decade, especially after the 1993 Revenue Reconciliation Act, which tremendously boosted the flow of funds into the system by allowing the participation of institutional investors in REITs. As a result, the industry experienced remarkable asset growth during the decade, with a large number of initial public offerings and substantial increases in market capitalization. Employing the Data Envelopment Analysis-type Malmquist index approach, this paper explores the impact of such environmental changes on productivity growth, efficiency change, and technological progress of REITs. Our results indicate that while efficiency of the REITs significantly increased, their average productivity declined and technology regressed during this decade. It appears that the typical REIT has failed to improve technically, but exerted substantial effort to catch up with the best practice ones relying mainly on aggressive growth strategies. However, our empirical results indicate that they might have overextended themselves as most began to suffer from diseconomies of scale.

Keywords REITs · Real Estate · Productivity · Efficiency · Technology · Malmquist Index · DEA

JEL Classification C67 · D24 · G23 · L11

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1 Introduction

The growth of Real Estate Investment Trusts (REITs) in the 1990s has been exceptional (Ambrose et al. 2000; Block 2002; Topuz et al. 2005; Ling and Archer 2005). Upon the introduction of many important regulatory reforms and favorable market conditions after 1993, the industry has witnessed significant consolidation and historical surge in assets and market capitalization, with strong implications on REITs productive performance. Using a panel data set from the period 1989 to 1999, this paper utilizes the methodology of *Malmquist index theory* to explore the effects of such structural and regulatory developments on the productivity and efficiency growth of REITs.

"*Every*body loves REITs" lately. In effect, these firms are *real estate mutual funds* that invest money (obtained through the sale of its shares to investors) in residential or commercial properties and earn primarily rent revenue (equity REITs), invest in property mortgages and earn principally interest revenue (mortgage REITs) or combine both investment strategies for shareholders (hybrid REITs). REITs have provided small investors with an opportunity to buy skyscrapers, shopping malls, hotels, restaurants and apartment buildings, without incurring the hassles of direct property ownership. With the all right essentials—consistent and remarkable profits, low volatility, impressive dividends, enhanced liquidity, low correlation with other investment classes, and most importantly professional management, REITs have become a part of *every* serious investor's diversified portfolio in recent years.

However, it took REITs about five decades to mature into solid citizens of the investment world. In 1960, the US Congress under President Eisenhower created these new institutions to promote real estate development by increasing public participation. The general public responded very favorably to this innovation and REITs were an enormous success in the late 1960s. However, after many mortgage REITs failed during the recession of 1973–1974, markets soon became disenchanted and lost interest in the entire REIT industry. The 1980s, characterized by the escalation of prices, overbuilding and poor performance, did not turn things around for REITs either. During the decade, the major blow came through the Tax Reform Act of 1986 that took away the tax-shelter advantage of REITs.[1] By the late 1980s, real estate sector was in "big trouble" (Block 2002).

Especially after 1993, numerous regulatory reforms have been launched to restore the attractiveness of REITs and boost their operational/managerial performance. Of these, the 1993 Revenue Reconciliation Act is the landmark and arguably most influential one for the industry (Topuz et al. 2005; Ling and Archer 2005). The original legislation of 1960 had exempted these special purpose trusts from corporate income tax if they met certain criterion, some of which later resulted in unintended

[1] The Economic Recovery Act of 1981 had created this tax advantage by authorizing property owners to use the vehicle of depreciation of their real estate as a tax shelter for other income. The 1960 act had mandated REITs to hire third parties to provide management and property leasing services. This restriction was lifted by the Tax Reform Act of 1986 by permitting REITs to own, operate and manage most commercial properties. As managers may have different economic interests than owners, it is believed that this law has created substantial agency problems for REITs [see Schulkin 1971], with adverse effects on their investment performance [see Solt and Miller 1985; Hsieh and Sirmans 1991; Howe and Shilling 1990].

consequences. To ensure diversified ownership, the original act had stated that a REIT's income would be taxable if five or fewer individuals owned more than 50%. This code made it difficult for large investors, like pension funds, to participate in REITs, hampering the flow of funds necessary for capital expenditures and expansions. The problem was partially solved by the creation of the Umbrella Partnership REIT (UPREITs) structure in 1992, which allowed investors to hold shares in the umbrella structure rather than in the trust's real estate.[2] However, it was the adoption of the Revenue Reconciliation Act in 1993, which has stimulated institutional investors such as pension funds to make large dollar investments in the REIT industry.[3]

As a reflection of favorable regulatory and business environment, the REIT market has exploded during the 1990s. Most notably, the 1993 Act broadly fostered the acceptance of REITs by mutual funds and other institutional investors, especially pension funds, paving the way for historical injection of funds into the industry. According to the statistics of the National Association of Real Estate Investment Trusts (NAREIT), the industry's leading trade organization, the industry has grown from 119 REITs with a market capitalization of $8.7 billion in 1990, to 203 REITs with a capitalization of $125 billion by the end of 1999, a 71% increase in the number of REITs and a stunning 1,322% increase in capitalization (see Table 1). The growth is more salient for equity REITs, with 188% increase in number and 2,030% in capitalization. This also manifests the trend of increasing scale in the REITs industry. Further evidence of the rise in the size and stature of the REIT market is the addition of the first REIT, Equity Office Properties, to the S&P 500 (in place of Texaco, Inc.) at the end of the decade.[4] According to industry experts, the inclusion of REITs in the S&P 500 is a significant step that underlines the spectacular growth of the real estate market in the 1990s and its increasing role in our financial system (Ling and Archer 2005).

The regulatory and structural changes after 1993 that have substantially altered the environment in which the REITs operate may have also resulted in notable

[2] The UPREIT structure allows real estate partnerships to become a REIT without imposing a tax liability on the individual partners. After creating an UPREIT, the partners have an option to receive units representing their ownership interests in the new trust. The properties' original owners can avoid taxes by retaining their partnership interests rather than converting them to shares in the UPREIT [see Kleiman 1993 for more detail]. After the 1993 Act, the REIT shares were considered to be owned by beneficiaries rather than by institution, allowing pension funds to become REIT owners.

[3] Other reforms of the decade were complementary in nature. With the REIT Simplification Act of 1997, the REIT operations have been further liberated by the U.S. Congress. One last impediment remaining in the way of the REITs' growth potential was in regard to distribution of earnings. The 1960 legislation had designed REITs as "pass-through enterprises" (to prevent double taxation); the law required that 95% of the rents from income property and/or interest income from mortgages had to be distributed to shareholders, further limiting the ability of REITs to retain earnings for future investments. The REIT Modernization Act (RMA) of 1999 finally reduced this dividend distribution requirement back to 90%. REITs initially had to distribute 90% of their taxable income to shareholders. This dividend payout requirement was later increased to 95% in 1980. The RMA of 1999 that became effective in 2001 reduced the dividend payout ratio back to 90%. This policy has provided the REITs with additional sources of income to retire some of their outstanding debt (Topuz et al. 2005).

[4] Since then, four additional REITs have been included in the S&P 500: Apartment Investment and Management, Equity Residential Properties, Plum Creek Timber and Simor Property Group.

Table 1 Market capitalization of the REITs industry

	Equity REITs		Mortgage REITs		Hybrid REITs		REITs Industry	
	No	Capitalization	No	Capitalization	No	Capitalization	No	Capitalization
1989	56	6,770	43	3,536	21	1,356	120	11,662
1990	58	5,552	43	2,549	18	636	119	8,737
1991	86	8,785	28	2,586	24	1,596	138	12,968
1992	89	11,171	30	2,773	23	1,968	142	15,912
1993	135	26,082	32	3,398	22	2,678	189	32,159
1994	175	38,812	29	2,503	22	2,991	226	44,306
1995	178	49,913	24	3,395	17	4,233	219	57,541
1996	166	78,302	20	4,779	13	5,696	199	88,776
1997	176	127,825	26	7,370	9	5,338	211	140,534
1998	173	126,904	28	6,481	9	4,916	210	138,301
1999	167	118,233	26	4,442	10	1,587	203	124,262

To be considered an equity (mortgage) REIT, at least 75% of the REIT investment portfolio must consist of income producing real property (mortgage instruments). Hybrid REITs combine the activities of equity and mortgage REITs. Source: National Association of Real Estate Investment Trusts

impacts on their operating performance. As mentioned, REITs have sought ways for rapid growth and economies of scale. However, as with any business, a key to successful performance for a REIT during expansion lies with the strength of its management. As firms grow very rapidly, managers usually do not have sufficient expertise and time to handle all operational details. Furthermore, operating overhead increases with faster growth. Isik and Hassan (2003c) provide evidence from the banking industry that asset growth rate is significantly and negatively associated with various measures of operational efficiency. Thus, many expanding REITs in the 1990s might have also outgrown their existing management skills. In addition, due to favorable market trends in real estate during the mid-1990s, investors poured money into REITs at unprecedented pace (Ambrose and Linneman 1998). If REITs had grown as a result of a rise in the market demand for real estate services, then greater demand might have allowed (tolerated) less efficient operations - at least in the short run. Furthermore, the business strategy of REITs during the 1990s was basically "growth through acquisitions", which resulted in a large wave of M&As. Vogel (1997) argues that the consolidation process observed in the 1990s is based on external, not efficiency related, factors. Evidently, Campbell et al. (1998) and Ambrose et al. (2000) found that these external growth attempts have not yielded positive returns or economies of scale for the REITs, suggesting the possible presence of self-dealing in many of these mergers. Therefore, the short-run outcomes of consolidation in the industry during the 1990s might have been unfavorable since they required a longer period to digest the newly acquired trusts and properly manage the transition period.

One important empirical inquiry to address is thus whether REIT productivity and efficiency has been affected in response to the regulatory and structural developments after 1993. If the remarkable REIT growth were achieved on the basis of the *same or less* productive resources, one should expect clear progress in operational performance. In other words, if REIT outputs and assets run faster "north" than did factor inputs during the decade, we should observe significant improvements in both

the productivity and efficiency of these new-born institutions. Moreover, if most of the M&As that took place during the decade resulted in scale economies, we should also detect an overall improvement in resource management in the industry. Yet, to the best of our knowledge, no empirical work has studied the impact of the changes that took place after 1993 on the *productivity, technology* and *efficiency growth* of the REITs. The purpose of this study is to examine the developments in the productivity as well as efficiency of the REITs using the nonparametric Malmquist Index method. Our technique allows us to consider in a dynamic setting both productivity growth at the frontier and the spread of productivity levels, as well as the diffusion of technology across the REIT industry. Bers and Springer (1997) and Linneman (1997) expected REITs to continue to grow in size and scale and become more competitive, with strong implications for scale economies/diseconomies in the industry. Hence, we also analyze the changes in the returns to scale of REITs during the period in order to see whether there are scale advantages to exploit by expanding or contracting operations.

Our empirical results indicate that the REIT industry has experienced productivity losses and contractions in their production frontier during this more liberal era. However, had it not been the "astonishing" efforts of inefficient REITs to catch up with the leading firms, the productivity fall would have been greater. Most of the overall efficiency gains were predominantly due to the march of typical REITs towards the optimum scale (scale efficiency increases) rather than efficient utilization of resources by management (technical efficiency rises). In addition, upon the launch of real estate reforms, we observed some improvements in production performance, especially in the "catching up effect" of the average REITs, probably due to the new regulatory and business environment that have broadened the opportunity set of services for all kinds of firms. Our analysis of returns to scale suggests that the times when efficiency gains were possible by just acquiring assets are over, as most of the REITs began to suffer from excessive size by the end of the decade. It appears that the "hot money" that fed the frenzy of asset acquisitions generously during the decade has left the industry, and the future viability and competitiveness of REITs will be increasingly dependent upon how well they are managed and how efficiently they are run.

"Section 2" provides literature review. We introduce the Malmquist methodology in "Section 3". "Section 4" discusses data and empirical design. In "Section 5", we examine the Malmquist index and its subcomponents along with some robustness checks. In "Section 6", we present our conclusions.

2 Literature review

As recognized by Berger and Humphrey (1997), who surveyed 130 efficiency studies on different financial institutions from 21 countries, earlier research has not dealt directly or indirectly with the productivity or efficiency performance of REITs despite the significant changes in their regulatory apparatus and phenomenal growth. However, a few static studies emerged in recent years that explore the determinants of the *efficiency level* for REITs [e.g., Anderson et al. (2002) and Topuz et al. (2005)]. However, none of these papers has dwelled on *efficiency growth* (catching

up or falling behind effect) or *technological progress* (outward shift or regress in REITs technological frontier) or *productivity gains* (rise in the ability of the REITs to generate more outputs from the same inputs), in the REIT's industry during this remarkable growth period. Besides, as discussed below and in the methodology section, productivity and efficiency concepts refer to different aspects of firm production.

Anderson et al. (2002) employed a linear-programming technique to measure efficiency of equity REITs for the period of 1992–1996. They reported technical efficiency scores ranging from 44% to 66% and scale efficiency from 74% to 83%. Consistent with Bers and Springer (1997, 1998a, b), most of the REITs were found to be operating on the increasing returns to scale portion of their production frontier. Their second stage regression showed that debt is negatively related to technical efficiency. However, the relationship between debt ratio and scale efficiency was positive. The authors found mixed results for diversified REITs, and concluded that REIT concentration increases efficiency by allowing more effective input utilization, but reduces the ability to take advantage of scale economies. Finally, internally managed and large REITs appeared to be more efficient. Extending the data until 1999 and using the same method as Anderson et al. (2002), Topuz et al. (2005), in their cross-sectional study, reported that REITs' efficiency improves with proper capitalization and separating management (decision) from board (control). While size appears to exert no influence on cost efficiency, the results indicate that scale efficiency of REITs goes down with size. The finding of positive and significant scale efficiency in medium (compared to large) REITs is consistent with that of Bers and Springer (1997), who suggested that economies of scale exist in the REIT industry but decrease with firm size.

Our study differs in terms of *data* (e.g., we use data from 1989 to 1999) and *focus*. We consider inter-temporal performance across years rather than cross-sectional performance in a given year (by exploring productivity growth and its constituencies before and after 1993). It should also be noted that although "efficiency" and "productivity" terms are interrelated and often used interchangeably, they refer to different aspects of production performance of decision-making units. A fully efficient firm may not be fully productive, as a firm may be technically efficient but may still be able to improve its productivity by exploiting scale economies (Coelli et al. 2003). Thus, it is widely argued in the literature that the productivity concept is superior to the efficiency concept in explaining production performance of an industry, which is undergoing important environmental transformations (Wheelock and Wilson 1999; Isik and Hassan 2003a, b). Thus, the use of productivity growth indexes for the REITs industry, which has experienced enormous changes in the 1990s, is critical for prudent empirical analysis. The trend in efficiency scores calculated with respect to year-specific frontiers would not accurately reflect the true impact of structural changes when the benchmark frontiers themselves are subject to change across years due to technical advances or de novo entries (Färe et al. 1994). Hence, comparing *efficiency* across years or REITs in the prior studies tells only part of the story because changes in distance function values from 1 year to another could be either (1) due to movements of REITs within input/output space or (2) due to technological change, i.e., shifts of the production frontier over time.

3 Measurement of the Malmquist productivity index

In practice, to measure productivity change in economic units, researchers employ two different performance indices, the stochastic Tornqvist (1936) index (a stochastic approach) or the non-stochastic Malmquist (1953) index (a non-stochastic approach). This study adopts the Malmquist index in examining the effects of the environmental changes on US REITs. Unlike the former approach, the Malmquist index uses quantity information exclusively and thus does not require neither problematic price information nor a restrictive behavioral assumption in its calculation. Employing a non-stochastic method, such as the Malmquist index, is advantageous relative to regression based techniques, like the translog and Cobb-Douglas cost functions, which may lead to model sensitivity and functional stability (Berger and Humhrey 1997; Wheelock and Wilson 1999; Isik and Hassan 2003a, b).[5] Our method also has informational advantage since it allows us to decompose both productivity growth and efficiency change indexes into their mutually exclusive and exhaustive subcomponents.

We do not know the optimum production technology of a fully efficient firm, thus we should estimate it from the observations in practice. To this end, we first map firms in an input-output space to detect the *best-practice firm* or the *production frontier* (i.e., technology), which depicts the maximum performance possible by firms.[6] Then, we contrast existing firms to this frontier because it represents the set of efficient observations for which no other production unit employs as little or less of every input without changing the output quantities generated or produces as much or more of every output without altering the input quantities. However, because of experience, increased knowledge, better production techniques, innovations, financial liberalization or chaos and heightened competition, production technology may change over time, resulting in shifts in the best practice technical frontier. Malmquist index allows us to distinguish between shifts in the production frontier (technology change, *techch*) and movements of firms towards the frontier (efficiency change, *effch*). Thus, Malmquist total factor productivity change index, *tfpch*, is simply the product of *effch*, how much closer a REIT gets to the efficient frontier (catching up or falling behind), and *techch*, how much the benchmark production frontier shifts at each REIT's observed input mix (innovation or shock).

We obtain the *techch* and *effch* indexes under the assumption of constant returns to scale (CRS), i.e., assuming that REITs operate at an optimum scale for cost minimization. However, in reality, REITs could face scale inefficiencies due to decreasing returns to scale (DRS) or increasing returns to scale (IRS) in their operations resulting from market or regulatory constraints. When we relax the CRS assumption and adopt the more realistic variable returns to scale assumption (VRS), we are able to decompose *effch* index into pure efficiency change (*pech*) and scale

[5] As the Malmquist index does not require the specification of a production or a cost function, it is relatively safe against *specification errors* that may be an issue for stochastic approaches. However, this index is susceptible to mixing of error term with inefficiency as all deviations from the frontier are deemed as inefficiency with no regard to data problems or pure luck.

[6] As REIT performance is not judged relative to some absolute standard, a best practice firm may not be fully efficient. Efficiency measures are relative in nature.

efficiency change (*sech*) components. The *pech* index measures the changes in the proximity of firms to the frontier, devoid of scale effects. The *sech* index indicates whether the movements inside the frontier are in the right direction to attain the CRS point, where changes in output result in proportional changes in costs. Briefly, *tfpch* = *techch* × *effch* and *effch* = *pech* × *sech*. Thus, *tfpch* = *techch* × *pech* × *sech*. Any value greater (lower) than 1 indicates a growth (fall) while any value equal to 1 indicates stagnation in the relevant index. We obtain the *tfpch* index and its subcomponents using the Data Envelopment Analysis (DEA) approach. *Effch*, *pech* and *sech* show the changes in technical efficiency (*eff*), pure technical efficiency (*pe*) and scale efficiency (*se*), which are calculated relative to both contemporary and previous year frontiers. Pure technical inefficiency, which is *eff* devoid of scale effects, is entirely under the control of and results directly from management errors. Thus, *pe* is also called *managerial inefficiency* in literature. It occurs when more of each input is used than should be required to produce a given level of output. It is typically attributed to insufficient competitive pressures that allow management to "get away" with slackened productivity. Because it involves the choice of an inefficient level, scale inefficiency is also considered a form of overall technical *in*efficiency. Hence, total technical inefficiency includes both pure technical and scale inefficiency; that is, inefficient level of both inputs and outputs. Table 2 summarizes the verbal definitions of all five Malmquist indices together with the three measures of returns to scale (RTS) used in this paper [since the DEA method is standard by now and relies on sophisticated set mathematics, please see our Appendix for brief mathematical definitions and refer to more technical studies, e.g., Färe et al. (1994) and Coelli et al. (2003), for further discussion on estimation of these indexes by DEA].

4 Data and empirical design

We collected our data from the printed copies of SNL REIT Quarterly for the years 1989 through 1999. As aforesaid, there are three types of REITs: equity, mortgage and hybrid. It is theoretically unclear if these different types of REITs possess identical frontiers. Because the Malmquist index measures the relative performance of the sample REITs with respect to a common frontier, it is only proper to study a *homogenous* set of REITs. Fewer than 10% of REITs fall into the special class of mortgage REITs and less than 5% into the hybrid ones. Because of missing data and the requirement of an efficient frontier for *like* REITs, we restrict our focus to equity REITs. This empirical approach is also adopted by Anderson et al. (2002) and Topuz et al. (2005). Consequently, over the 11-year study period, our balanced (unbalanced) panel data set covers 561 (1,065) observations with full information regarding 51 (97) equity REITs per year.

In order to construct a common frontier against which all REITs will be compared, we first need to specify the factors of production (inputs) these institutions employ and the products and services (outputs) they generate. Nevertheless, in practice, selection of inputs and outputs is most often dependent upon the researcher's interest, view of firms, and at times upon the availability of data (Aly et al. 1990). This issue is an ongoing discussion in financial institutions

Table 2 Definition of Malmquist indexes and returns to scale measures

Terms	Symbol	Definition
Malmquist indexes		
Total factor productivity change	tfpch	tfpch is a product of technological change (techch) and efficiency change (effch). Thus, productivity growth could be a result of an expansion in frontier due to technological advances or of catching up effect of inefficient firms with better ones or both
Technological change	tecch	techch is an upward/downward shift in production frontier, which may result from technical innovations and IT investments. A technical progress may occur if the production frontier expands upward, and a technical regress if the frontier contracts downward.
Efficiency change	effch	effch represents the changes in the proximity of economic units (changes in technical efficiency) to the CRS production frontier. Firms may catch up with the leading firms if they get closer to the frontier, and fall behind if they get away from the frontier
Pure efficiency change	pech	pech depicts the changes in the proximity of firms to the VRS efficient frontier (changes in pure technical efficiency) devoid of scale changes, thus virtually represents changes in managerial skills "to do more with less"
Scale efficiency change	sech	sech exhibits the efforts of firms to move to the optimum scale where there are constant returns to scale; it is in essence the degree to which VRS and CRS frontiers converge
Efficiency indexes		
Technical efficiency	te	te is a product of pte and se and occurs when input usage cannot be decreased without decreasing output.
Pure technical efficiency	pte	the deviation from the efficient production frontier due to inefficient input utilization
Scale efficiency	se	occurs when total outputs cannot be altered without increasing average costs.
Returns to scale measures		
Constant returns to scale	CRS	occur when 1% increase in inputs results in exactly 1% increase in outputs
Increasing returns to scale	IRS	happen when 1% increase in inputs produces more than 1% increase in outputs
Decreasing returns to scale	DRS	arise when 1% increase in inputs leads to less than 1% increase in outputs.

We use Data Envelopment Analysis (DEA), a mathematical frontier technique, to estimate the above variables. Please refer to Färe et al. (1994) and Coelli et al. (2003) for how to calculate these scores using the respective method

literature. For instance, banking literature has not come to a consensus yet on the definition of bank inputs/outputs although there were over 130 frontier efficiency and productivity studies as of 1997 (Berger and Humphrey 1997).[7] Not surprisingly, rather limited number of the REITs frontier studies also does not provide a

[7] For example for banking firms, the literature provides two main procedures, *production approach* and *intermediation approach*, to select appropriate inputs and outputs in DEA-based estimations. *Production approach* considers banks as firms producing services for customers such as performing transactions and processing documents. Therefore, inputs are measured by physical units, and outputs are measured by the number and type of transactions or documents processed over a given time period. Under the alternative *intermediation approach*, banks are viewed as the conduit of funds between depositors and borrowers. Banks thus incur labor, capital and loanable funds expenditures to transfer funds from those with surplus of funds to those with shortage of funds.

consensus as to what really signifies the production of REITs, or how to measure their output(s).[8]

The researchers usually choose different types of assets and dividends as REIT output although there are other potential candidates such as market capitalization, market capitalization minus debt, and space measures such as square footages. Springer (1998) cites at least three reasons for choosing total assets to market capitalization as an appropriate measure. First, total assets are highly correlated with market capitalization. Second, total assets exhibit lower variance and yield more consistent results. And thirdly, estimates based on total assets are generally less biased.[9] As a matter of fact, Bers and Springer (1997) in their scale economy study and Anderson et al. (2002) in their efficiency study find that results are very similar when both total assets and dividends are used as outputs or when only a single output of total assets is used.[10] Hence, we measure the REITs' output by using *total assets*. However, we decompose total assets into three categories: real estate loans (L), properties in operation (P), and other assets (OA).[11] We believe that these three outputs are particularly suitable for analyzing REITs' managerial efficiency and productivity since revenue generated from them (rent and/or interest) virtually depends on managerial decisions. Following the examples from bank efficiency studies [e.g., Miller and Noulas (1996) and Avkiran (1999)] and our two predecessors, we use the following two inputs in our model; interest expenses (IE) and property operating expenses (POE). Interest expense is the cost of debt and other borrowings including the amortization of debt discounts, while property operating expenses include maintenance, utilities bills, management fees, and property taxes on rental properties. Thus, total expenses serve to proxy the traditional input factors of labor, capital and materials.[12]

We preferred to be parsimonious in the number of inputs and outputs, as more variables in the DEA framework hinder the ability of the model to distinguish between best and worst-practice units (Coelli et al. 2003; Isik and Hassan 2003c).[13] Table 3 provides statistical summaries of inputs and outputs over the estimation period. As it appears, loan production declined from $18 million in 1989 to $3.5

[8] It is also debatable among academicians as to whether REITs are stock investment or real estate institutions. However, recent studies [e.g., Ghosh et al. (1996); Bers and Springer (1997, 1998a, b) and Anderson et al. (2002)] exceedingly argue that REITs are real estate investments rather than stocks.

[9] Since REITs encountered phenomenal growth during the study period, any downward bias in asset values should be insignificant, i.e., the costs of the assets should be relatively current. Please, refer to Springer (1998) for a detailed discussion about the justification of possible REIT outputs.

[10] In order to control for input/output specification issues further, we have also used at least four other different combinations and our major results were sustained. Due to space issues, these results are not reported here but available from the authors upon request.

[11] The other assets category includes non-operational properties such as land for sale or under development, unconsolidated partnership or joint ventures, and all non-real estate assets.

[12] In order to prevent the adverse impact of inflation on our time-series analysis of productive performance, we adjust our production variables for "purchasing powers loss" using the 1989 prices.

[13] Actually, Anderson et al. (2002) use four inputs: interest expense, operating expense, general and administrative expense, and management fees, whereas Topuz et al. (2005) employ interest expense and operating expenses.

Table 3 Summary statistics of production variables ($ 000)

Variables	Years										
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Outputs											
Loan	17,997	14,362	6,808	4,317	3,522	4,618	6,863	9,639	17,796	23,216	24,548
	(29,446)	(24,672)	(14,051)	(9,765)	(8,112)	(12,521)	(21,906)	(29,785)	(51,246)	(103,079)	(98,670)
Properties	242,262	152,055	181,089	211,168	271,235	316,068	424,952	575,425	919,226	1,304,573	1,471,796
	(118,274)	(125,286)	(153,388)	(214,065)	(264,098)	(339,545)	(463,724)	(674,675)	(1,267,345)	(1,877,085)	(2,118,428)
Other assets	28,009	22,818	22,189	24,700	34,896	36,437	56,367	74,501	126,625	194,578	245,219
	(48,380)	(39,219)	(43,541)	(53,376)	(61,790)	(58,973)	(91,027)	(113,639)	(214,176)	(347,445)	(408,601)
Total output	288,268	189,235	210,086	240,185	309,653	357,123	488,182	659,565	1,063,647	1,522,367	1,741,563
Inputs											
Interest expense	7,918	6,929	11,705	13,332	13,145	9,223	15,067	17,010	22,998	37,087	50,830
	(8,669)	(8,327)	(12,022)	(19,105)	(22,986)	(15,922)	(24,101)	(22,842)	(32,890)	(54,998)	(81,331)
Property operating expense	7,260	7,717	10,468	12,145	14,399	15,240	23,780	27,327	41,402	56,013	66,674
	(7,299)	(7,254)	(9,737)	(14,282)	(20,303)	(20,931)	(36,174)	(39,995)	(71,541)	(86,015)	(103,304)
Total input	15,178	14,646	22,173	25,477	27,544	24,463	38,847	44,337	64,400	93,100	117,504

Outputs: Loans are the value of all real estate loans; properties are all properties in operation owned by the company; other assets are non-operational properties, including properties under development, land held for development, and property held for sale, unconsolidated partnership (joint ventures), and all non-real estate investment assets. Inputs: Interest expense is the interest paid on debt and other borrowings, including amortization of debt discounts; property operating expense is the costs associated with operating rental properties including maintenance costs, utilities, property management fees, and real estate taxes. Standard deviations are in parentheses

L Loans, *P* properties, *OA* other assets, *IE* interest expense, *POE* property operating expense

million in 1993, but then increased to $25.5 million in 1999 following a U-shaped pattern. Because of falling interest rates during the 1989–1993 period, REITs preferred purchasing property by using less expensive funds than making loans with low interest rates. As a result, property values dominated loans by a factor of 78 in 1993 compared to 7 in 1989, and interest expenses doubled between 1991 and 1993. The initial causal observation from the table implies a deterioration in the productivity of REIT factor inputs as the total inputs grew faster (by about 600%) than did total outputs (by about 500%) between the first year, 1989 and last year, 1999 of the decade.

Because the Malmquist index requires that a REIT exist in two successive years, we use a *balance* panel data set. In doing so, we examine the productivity adventure of the *same* set of REITs during the 1990s. There are 51 such REITs that continuously exist until 1999. Despite some loss of information, this empirical treatment has some important analytical advantages in productive efficiency studies.[14] First, as can be observed from Table 1, the market structure of the industry has been very volatile during the decade due to a substantial number of new entries (e.g., the number of equity REITs ranged from the lowest 56 in 1989 to the highest 167 in 1999). Given the fluctuating and inconsistent sample size, if "static" efficiency scores (calculated only with respect to each year's annual frontier) are used, inter-temporal comparison of performance could be biased (Wheelock and Wilson 1999). If we wish to study, however, two REITs in a given year, say 1999, using the reference technology of all the REITs observed in 1999, then a direct comparison of efficiency is possible. In this case, the efficiency of the two REITs is measured vis-à-vis a common frontier formed with an identical sample of REITs in 1999. In contrast, if a REIT is observed in both 1998 and 1999, annual efficiency measures are computed with different benchmark samples (and thus frontiers) of REITs. Thus, a comparison of efficiency scores across years may not be an indicator of *absolute improvement* of efficiency or productivity. Such static analysis could only display changes in the relative efficiency of that specific REIT vis-à-vis that of other REITs between 1998 and 1999. Therefore, in order to determine absolute improvement in productive performance across time, the Malmquist productivity index is commonly preferred to traditional efficiency measures in time-series analyses (Berger and Humphrey 1997; Canhoto and Dermine 2003; Isik and Hassan 2003b). In Malmquist methodology, the data set remains the same but time periods change, making it possible to compare REITs against a common frontier. Second, as Coelli et al. (2003) note, the DEA efficiency scores tend to increase upward as the sample size decreases. Given the constantly increasing number of REITs throughout the 1990s, using a balanced panel data set is critical to control for such an upward bias for earlier years (and downward bias for later years) of the decade.[15]

[14] There are 51 (26) such REITs that continuously exist until 1999 (1993).

[15] As a further caveat, the contamination of results with noise in the data resulting from the arrival of new entries could be more serious. As demonstrated by DeYoung and Hasan (1998), as compared to established peers, de novo firms are destined to have erratic behavior and lower efficiency in their early years, which may last as long as 9 years.

5 Empirical analysis of the Malmquits productivity indexes

Table 4 exhibits the estimates of *tfpch* and its sub-components, namely *effch*, *techch*, *pech* and *sech* of the REITs for the period 1989–1999. As discussed, the Malmquist index cannot be computed without a *reference* frontier (technology), which can be the frontier of any year in a multi-period setting. In this study, we use two reference technologies; a *changing* (successive) reference technology (Panel A) and a *fixed* reference technology (Panel B). The changing (successive) reference technology uses each of successive 2 years, e.g., the frontier is fixed in 1989 and compared to 1990, and then fixed again in 1990 and compared to 1991, and so on. In the fixed reference technology, the frontier is fixed in 1989 and compared to the years from 1990 to 1999 in the input-output space, i.e. the efficiency and productivity changes are calculated in 1990, 1991, 1992, etc. relative to the base year 1989. The successive frontier results are used to address the inquiry of what the annual rates of growth (fall) in each index have been, while the fixed frontier results aim to answer the question if the relevant indexes have improved (worsened) during the decade as compared to where we had started (reference year). For both cases, we provide three means, two for sub-periods 1989–1992 and 1993–1999, and one for the whole period, 1989–1999. The implicit assumption in our analysis is that 1993 is a *demarcation point* for the REITs when the industry began to witness a number of important liberal reforms. In order to determine the statistical significance of improvements over time in relevant indexes, we have used analysis of variance tests for the differences of annual means as well as grand means of the two sub-periods. By dividing the whole period into two, we tested for a *level of shift* in productive performance especially after 1993, when the Revenue Reconciliation Act was put

Table 4 Average total factor productivity change in REIT industry during 1989–1999

Panel A: changing reference technology						Panel B: fixed reference technology		
Period	effch	techch	pech	sech	tfpch	Period	techch	tfpch
89–90	1.013	0.875	0.915	1.107	0.886	89–90[bs]	0.875	0.886
90–91	1.015	1.010**	1.013*	1.002**	1.025	89–91	0.883	0.908
91–92	1.162*	0.810	1.087***	1.069	0.941	89–92	0.746***	0.891
92–93	1.039	1.004***	0.914	1.137	1.043**	89–93	0.732***	0.908
93–94	1.815***	0.638	1.128***	1.609***	1.157***	93–94	0.638***	1.157
94–95	0.721***	1.139***	1.006*	0.716***	0.821*	93–95	0.803***	1.050
95–96	1.755*	0.565**	0.970*	1.809	0.992*	93–96	0.435***	0.998
96–97	1.064***	1.045***	1.053	1.011***	1.112*	93–97	0.461***	1.125
97–98	1.279***	0.666	1.027*	1.245***	0.852**	93–98	0.300***	0.938
98–99	1.104***	0.876***	1.077	1.025***	0.968**	93–99	0.287***	0.991
Mean								
89–93[bs]	1.057	0.925	0.982	1.079	0.974	89–93[bs]	0.809	0.898
94–99	1.290**	0.822	1.044	1.236***	0.984	94–99	0.487***	1.043**
89–99	1.197	0.863	1.019	1.173	0.980	89–99	0.616	0.985

bs Refers to the base year (period) with which all other years (periods) are compared statistically. We used ANOVA tests to test the significances

effch Efficiency change, *techch* technological change, *pech* pure efficiency change, *sech* scale efficiency change, *tfpch* total factor productivity change

*p=0.10, **p=0.05, ***p=0.01 between the means of the base year (period) and respective year (period)

into force, which tremendously boosted the flow of funds into the system by allowing the participation of institutional investors in REITs.

With respect to the changing reference technology (Panel A of Table 4), we observe that the REITs in our sample experienced a 2% *productivity fall*, a 14% *technological regress*, a 19% *efficiency increase*, a 2% *pure efficiency increase* and a 17% *scale efficiency increase* on average between 1989–1999. It is clear that the productivity fall of the sector in the 1990s would have been worse had it not been for the impact of efficiency increases—catching up effect (as the frontier contracted drastically).[16] For the entire period, our results presents a similar picture with respect to fixed reference technology (Panel B of Table 4), with falling productivity and a contracting technological frontier, but with greater technical regress (about 38% regress) when compared to the basis year of 1989.[17] These results indicate that the main cause of the productivity decline for the US REITs during the decade was the contraction in their technology; the REIT frontier regressed with respect to successive years on average in all but four cases during the 11 years (1991, 1993, 1995 and 1997). Despite the disappointment in technological performance, the REITs *appear* to have demonstrated remarkable efficiency gains, partly owing to the contraction of the frontier. REITs registered overall efficiency increase in every year during the 11-year period except for 1995. Likewise, scale efficiency increase was always positive during the period except for 1995. It appears that the cardinal driver behind the REITs' stunning efficiency performance was scale efficiency increases (movement of the REITs towards the optimum scale where there are constant returns to scale, CRS), rather than pure efficiency increases (movement of the REITs to the efficient frontier due to improvements in managerial performance).

Other things held constant, the impact of liberal reforms (launched from 1993 and onward) on REITs performance was significantly positive especially for overall efficiency—*effch* (annual 29% efficiency increase in 1994–1999 versus 6% in 1989–1993). This positive outcome in efficiency stems mainly from movements towards the efficient CRS scale—*sech* (annual 24% scale efficiency increase in 1994–1999 versus 8% in 1989–1993). Although not statistically different from the prior period, technical regress in 1994–1999 seems to have exacerbated (28% versus 7%), and remains as the main reason for the overall 2% productivity decline during the period. According to the estimates from the fixed reference frontier (Table 4-Panel B; *techch* and *tfpch*), technological regress is more dramatic, 51% versus 19% between the two

[16] The controversial coexistence of both technical regress and efficiency increase is explained theoretically with a graph in the Appendix. The REITs in our sample experienced a 14% downward shift in their CRS frontier and a 19% rise in their CRS efficiency (proximity to this frontier). This indicates that 14% of efficiency increase became possible with the shrinkage of the CRS efficient frontier. This in turn implies that REITs have achieved only 5% of the total trip towards the efficient frontier. If the VRS frontier against which pure efficiency measures are calculated also shrunk by 14%, with the same analogy, the net scale efficiency increase becomes only 3% and net pure technical efficiency increase becomes a decrease of 12%.

[17] As both technologies suggest similar productivity growth, the larger magnitude of technical regress with fixed technology actually implies greater importance of efficiency increase in driving productivity. Since the technological regress is the dominant source of the productivity decline, we reported only two indexes from the fixed frontier results. Other efficiency estimates (*effch*, *pech*, and *sech*) are available upon request from the authors.

periods. However, the productivity performance seems to have improved significantly in the second period as compared to the basis year (4% gain versus 10% fall) with respect to 1989. These results provide some empirical evidence that the effects of the reforms were in general favorable for the REITs industry, particularly in terms of efficiency, mainly as a result of the march of the REITs towards the input minimizing optimal scale (i.e., scale efficiency increases). However, the relative productivity growth and especially technical progress of the industry were less than impressive.[18]

Although an analysis based on the aggregation of results (averages) for the whole and sub-periods is helpful, it hides some important developments in the sector's annual performance. Emerging from the 1980s real estate excesses, REITs did not begin the 1990s well (Block 2002).[19] REIT shareholders suffered through a bear market in 1990, when REIT operations shrunk considerably, as evidenced by 34% fall in total outputs and 4% in total inputs (see Tables 3 and 7). This seems to have deteriorated REIT productivity as output decline outpaced input decline. The net impact was an 11% reduction in *tfpch*, a 12.5% regress in frontier (*techch*) and a 8.5% fall in management efficiency (*pech*) in 1990. However, upon the introduction of the Revenue Reconciliation Act in 1993, investors, especially pension funds, poured money into REITs at an unprecedented pace (NAREIT statistics).[20] Institutional buying and selling has had a major impact on the REIT market. As can be observed from Tables 1 and 7, REITs' market capitalization has more than doubled (by 178%) and total outputs rose by half (48%) between 1992 and 1994. This occurred while total inputs picked up modestly (by only 8%) in 1993 and fell sharply in the following year (11%). The favorable environment helped REITs record their largest productivity improvement (16%) as well as greatest technical efficiency (82%), pure efficiency (13%) and scale efficiency (61%) rises of the decade in 1994. However, all these improvements were predominantly accomplished by the REITs under the frontier, while the leading REITs that reside on the frontier failed to capitalize on this bonanza (as evidenced by 36% technical regress).

Furthermore, according to industry experts (NAREIT), the zenith year of the sector was 1997.[21] Our results indicate that the second best productivity performance occurred in this year. All five indexes enjoyed improvements for the first time in the second half of the decade that year. However, by 1998, the REIT industry's fortune reversed, as investors worried that REITs were bidding up real estate prices too fast, potentially setting the stage for a downturn. Furthermore, global financial crisis in

[18] It may also be argued that the regulatory reforms may merely change the input mix. Unless REITs use a Leontief production function in which inputs are not substitutable, these regulatory actions merely force the REITs toward a (likely) less efficient input mix.

[19] The poor start in 1990 is attributed to overbuilding in office and apartment sectors, causing rising vacancies and reduced rents. In the retail sector, the blame was on Wal-Mart and other discounters as they marched into the turf of traditional retailers, all of which caused overreaction by investors.

[20] This influx of money attracted the highest number of new comers to the sector in the decade in those years, with 50 IPOs in 1993 and 45 in 1994.

[21] The hot market for REIT stocks in 1997 may have been a prediction of higher property values ahead. The strong involvement of institutional investors was also note-worthy since in 1996–1996, pension funds began setting up new business devoted solely to the management of REIT portfolios in 1996–1997. The trend of public securitization of real estate had become indelibly established by 1997 (Block 2002).

1998 in Asia, Russia, and Latin America caused many banks to tighten their lending policies, making it harder and more expensive for REITs to borrow, thus increasing further their costs of inputs. Meanwhile, skyrocketing high-tech stocks lured investors away from real estate. As these pressures converged, investors began to pull out of REITs and share prices tumbled by 20% between 1998–1999 (their worst performance since 1973–1974). Our results from both reference frontiers confirm these developments as the productivity of the sector fell sharply in these years. The technology performance of the sector was also lowest in 1998 and 1999.

5.1 Robustness checks of the empirical results

An analysis based on averages can be susceptible to extreme observations (outliers) as only a few REITs may be responsible for overall results. An analysis based on percentages (or numbers), however, is less sensitive to such outliers. Assume that an industry is made up of only four REITs A, B, C, and D, whose productivity change scores are 0.7, 0.8, 0.9 and 1.8, respectively. These scores indicate that while the firms A, B, and C suffered productivity loss, REIT D registered an extreme productivity growth. The results based on average would suggest that the industry experienced 5% productivity gain as the average of these four scores is 1.05. Whereas, the results based on percentages (numbers) would correctly suggest that 75% of REITs in this industry experienced a productivity decline while only 25% recorded a productivity rise. In order to explore the impact of possible extreme observations, we follow Isik and Hassan (2003a, b) and we examine the changes in the *number* of REITs that experienced a productivity gain or loss during the period 1989–1999.

As the changing frontier results in Table 5-Panel A (fixed frontier results of Panel B are in parentheses) show, 59% (54%) of the REITs realized a productivity loss, while 41% (46%) recorded a productivity gain during the decade, confirming our earlier results of an overall productivity decline in the sector. The severity of the technical regress is also apparent, on average, 56% (87%) regress versus 42% (13%) progress. As for efficiency, *sech* are again the defining development behind the overall *effch*, as the great majority, plainly 60% (74%), of the REITs somewhat registered an improvement in their scale. According to both technologies, the sub-period results also attest that the REITs' productive performance was generally enhanced in more liberal environment of the second half of the decade (probably with the escalation of reforms).

Table 6 further breaks down Table 5 to closely trace the main sources of productivity and efficiency change as well as test the robustness of our earlier conclusions. Based on changing reference technologies (Panel A), the dominant source of productivity growth (loss) in the REIT industry seems to be an efficiency increase (technological regress) over the entire period. For instance, of the 41% REITS (observed in Table 5, Panel A, column 2) that realized *productivity growth*, 73% owe it to efficiency increase while only 17% owe it to technical progress (Table 6, Panel A, columns 2 and 3).[22] The results also indicate that the dominant

[22] We find 73% by dividing 30% by 41%, and 17% by dividing 11% by 41% in Table 6.

Table 5 Changes in the number of REITs with productivity gain/loss or efficiency increase/decrease

	Productivity change (%) (*tfpch*)			Technology change (%) (*techch*)			Efficiency change (%) (*effch*)			Pure efficiency change (%) (p*effch*)			Scale efficiency change (%) (*sech*)		
Period	Growth	Loss	No Δ	Progress	Regress	No Δ	Inc.	Dec.	No Δ	Inc.	Dec.	No Δ	Inc.	Dec.	No Δ
Panel A: With respect to changing frontier															
89–90	19	81	0	35	65	0	35	50	15	15	43	42	65	20	15
90–91	42	58	0	50	50	0	42	38	20	27	27	46	38	42	20
91–92	50	50	0	8	92	0	73	15	2	50	19	31	65	23	12
92–93	42	58	0	62	38	0	50	38	12	27	46	27	73	15	12
93–94	45	55	0	10	90	0	63	33	4	37	47	16	76	20	4
94–95	33	67	0	61	39	0	27	67	6	41	39	20	25	69	6
95–96	51	49	0	2	98	0	90	4	6	35	51	14	76	18	6
96–97	63	37	0	57	35	8	57	43	0	45	37	18	43	49	8
97–98	27	73	0	74	18	8	2	98	0	49	27	24	76	16	8
98–99	39	61	0	63	31	6	24	76	0	55	27	18	59	31	10
Mean															
89–93	38	62	0	39	61	0	50	35	12	30	34	37	60	25	15
94–99	43	57	0	45	52	4	44	54	3	44	38	18	59	34	7
89–99	41	59	0	42	56	2	46	46	7	38	36	26	60	30	10
Panel B: With respect to fixed reference frontier															
89–90	19	81	0	35	65	0	35	50	15	15	42	42	65	19	16
89–91	35	65	0	42	58	0	46	38	15	19	38	42	65	19	16
89–92	42	58	0	0	100	0	65	23	12	42	27	31	69	19	12
89–93	50	50	0	0	100	0	58	27	15	30	35	35	73	12	15
93–94	45	55	0	10	90	0	63	33	4	37	47	16	76	20	4
93–95	45	55	0	29	71	0	49	45	6	45	39	16	49	45	6
93–96	57	43	0	6	94	0	74	22	4	45	41	14	84	12	4
93–97	61	39	0	2	98	0	78	18	4	43	47	10	84	12	4
93–98	55	45	0	2	98	0	78	18	4	41	49	10	86	10	4
93–99	55	45	0	4	96	0	82	14	4	55	35	10	86	8	6
Mean															
89–93	37	64	0	19	81	0	51	35	14	27	36	38	68	17	15
94–99	53	47	0	9	91	0	71	25	4	44	43	13	78	18	5
89–99	46	54	0	13	87	0	63	29	8	37	40	23	74	18	9

REITs are classified according to the following: Productivity growth: *tfpch*>1, productivity loss: *tfpch*<1, no change in productivity: *tfpch*=1; technological progress: *techch*>1, technological regress: *techch*<1, no change in technology: *techch*=1; technical, pure and scale efficiency increase: *effch*, *pech*, and *sech*>1; technical, pure and scale efficiency decrease: *effch*, *pech*, and *sech*<1, no change in technical, pure and scale efficiency: *effch*, *pech*, and *sech*=1

source of *efficiency increase* during the decade is a scale efficiency increase rather than a pure efficiency increase. For example, of the 46% REITs (observed in Table 5, Panel A, column 8) that achieved efficiency increase during the decade, the great majority, 80%, owe it to scale efficiency while only 20% owe it to pure efficiency increase (Table 6, Panel A, columns 7 and 8). The results also imply that the major source of *productivity loss* is again technical regress. Of the 59% REITs (Table 5) that experienced a productivity decline, 61% incurred it due to technical regress while 39% suffered it due to efficiency decrease. We also observe that the major cause of *efficiency decrease* is managerial rather than scale-related. The results from

Table 6 Productivity and efficiency sources in REITs

Period	Productivity growth (%) mainly due to:		Productivity loss (%) mainly due to:		NO Prod. (%) Δ	Efficiency increase (%) mainly due to:		Efficiency decrease (%) mainly due to:		NO Eff. (%) Δ
	Eff. Incr.	Tech. Progress	Eff. Decr.	Tech. Regress		PTE Incr.	SE Incr.	PTE Decr.	SE Decr.	
Panel A: With respect to changing frontier										
89–90	15	4	38	43	0	4	31	35	15	15
90–91	23	19	31	27	0	19	23	19	19	19
91–92	42	8	12	38	0	27	45	4	12	12
92–93	43	0	38	19	0	12	37	31	8	12
93–94	43	2	18	37	0	16	46	22	12	4
94–95	14	20	46	20	0	12	16	12	54	6
95–96	48	2	0	50	0	16	74	2	2	6
96–97	18	45	27	10	0	34	22	18	18	8
97–98	25	2	4	69	0	16	58	14	4	8
98–99	29	10	18	43	0	48	14	24	8	6
Mean										
89–93	31	8	30	32	0	16	34	22	14	15
94–99	30	14	19	38	0	24	38	15	16	6
89–99	30	11	23	36	0	20	37	18	15	10
Panel B: With respect to fixed reference frontier										
89–90	15	4	38	43	0	4	31	35	15	15
89–91	31	4	34	31	0	8	38	27	12	15
89–92	42	0	4	54	0	15	50	8	15	12
89–93	50	0	12	38	0	15	43	23	4	15
93–94	43	2	18	37	0	16	46	22	12	4
93–95	36	10	27	27	0	22	27	20	25	6
93–96	53	4	12	31	0	14	60	18	4	4
93–97	59	2	8	31	0	16	62	16	2	4
93–98	53	2	0	45	0	18	60	18	0	4
93–99	51	4	0	45	0	16	66	14	0	4
Mean										
89–93	35	2	22	42	0	11	41	23	12	14
94–99	49	4	11	36	0	17	54	18	7	4
89–99	43	3	15	38	0	14	48	20	9	8

Productivity growth due to technological progress(efficiency increase): *tfpch*>1, and *techch*>1 and *effch* (*tfpch*>1, and *effch*>1 and *techch*); productivity loss due to technological regress (efficiency decrease): *tfpch*<1, and *techch*<1 and *effch* (*tfpch*<1, and *effch*<1 and *techch*); efficiency increase due to PTE increase(SE increase): *effch*>1, and *pech*>1 and *sech* (*effch*>1, and *sech*>1 and *pech*; Efficiency decrease due to PTE decrease(SE decrease): *effch*<1, and *pech*<1 and *sech* (*effch*<1, and *sech*<1 and *pech*)

the fixed reference frontier (Table 6, Panel B) demonstrate similar implications on the dominant source of productivity (efficiency) gain or loss, but with a sharper tone (e.g., the main driver of productivity gain is again efficiency increase but this time, the REITs with productivity growth mainly due to improved efficiency reach 93% rather than 73% as noted above). As for sup-period results, in the 1994–1999 period, the percentage of REITs with productivity growth mainly due to an efficiency increase improved. Similarly, those REITs with productivity loss mainly due to technological regress also increased. In the second half of the decade, the percentage of REITs with efficiency increases mainly due to scale efficiency increases improved

for the changing reference frontier (by 17%) and the fixed reference frontier (19%), thus implying that new developments in the industry seem to have played a positive impact on REITs' scale efficiency.

As a robustness check for "survivorship bias" that may arise from the nature of balanced panel data, we also employed the largest sample possible by twisting the methodology with the help of successive reference frontiers. In other words, we looked at sector performance in 2-year time intervals at a time; which of course resulted in a different sample composition (and frontier) for every 2-year bundles. However, this way, we were able to include all the REITs; including those that exited the industry either via failure or M&As or those newly entered into the market. The number of firms in our "full sample" ranged from 69 in 1991 to 132 in 1999. We found that the overall results and trends were well preserved; the dominance of technical regress in causing productivity decline and superiority of scale efficiency increases in driving overall efficiency were persistent in this alternative application (the full results are available from the authors upon request).

Because REITs represent multi product institutions, when we used the term productivity in this study, we meant the Malmquist *total factor productivity* (*tfp*), a productivity measure that takes into account *all* factor inputs, rather than *partial productivity*, a productivity measure that considers only one factor input (such as labor productivity). However as sophisticated and complicated as the Malmquist *tfp* index is, it should be closely related to the proxy (raw) measure of total productivity (*tfp**): "total outputs" (TO) divided by "total inputs" (TI), as they aim to measure the same aspect of firm performance.[23] In order to complement our robustness analysis, we summed up all our outputs and all our inputs for the industry and obtained our proxy measures of total factor productivity: *tfp** = TO/TI and total factor productivity change: *tfpch** = percentage change in *tfp** between 2 years = [(*tfp**2/*tfp*1*)-1]. We presented the annual proxy results along with the Malmquist *tfpch* indexes in Table 7. As can be seen, throughout the 11-year period, except for two cases, 1991 and 1996, the proxy measures of total factor productivity change were of the same sign and direction with the Malmquist *tfpch* index; i.e., when the *tfpch* implied rising (declining) productivity, so did the proxy measures (*tfpch**). Most importantly, the proxy measures of productivity change (*tfpch**), either computed successively or relative to the base year, attest to the main conclusion of our analysis: REIT productivity on average declined in the 1990s in spite of the phenomenal market growth.[24] The proxy measures were also capable of detecting the poor productivity performance of REITs during the bear markets of 1990, 1998 and 1999, as raw scores are significantly negative in these years. They also caught the remarkable performance of REITs in 1994 and 1997, as did the Malmquist

[23] The computation of Malmquist productivity for a multi-output/multi-input firm is clearly more difficult than for single output/single input firm as one needs to aggregate the multiple outputs into a "virtual output", VO, and multiple inputs into a "virtual input", VI, where *tfp*=VO/VI (Coelli et al. 2003).

[24] The 0.5% annual fall in productivity with proxies compares well with the 2% fall with the Malmquist *tfpch* index. However, with respect to the reference year 1989, the proxy measures imply a severe decline (30%) as compared to 1.5% fall with the Malmquist.

Table 7 Malmquist total factor productivity change (*tfpch*) index and proxy measures of productivity

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Total outputs (TO)	288,268	189,235	210,086	240,185	309,653	357,123	488,182	659,565	1,063,647	1,522,367	1,741,563	642,716
Total inputs (TI)	15,178	14,646	22,173	25,477	27,544	24,463	38,847	44,337	64,400	93,100	117,504	44,334
Raw productivity = *tfp**	18.99	12.92	9.47	9.43	11.24	14.60	12.57	14.88	16.52	16.35	14.82	13.80
Δ Raw productivity (*tfpch**)àsuccessive	–	−31.97%	−26.67%	−0.50%	19.25%	29.86%	−13.92%	18.38%	11.02%	−0.99%	−9.36%	−0.49%
Δ Malmquist productivity (*tfpch*)àsuccessive	–	−11.40%	2.50%	−5.90%	4.30%	15.70%	−17.90%	−0.80%	11.20%	−14.80%	−3.20%	−2.00%
Δ Raw productivity (*tfpch**)àfixed	–	−31.97%	−50.11%	−50.36%	−40.81%	−23.14%	−33.83%	−21.67%	−13.04%	−13.90%	−21.96%	−30.08%
Δ Malmquist productivity (*tfpch*)àfixed	–	−11.40%	−9.20%	−10.90%	−9.20%	15.70%	5.00%	−0.20%	12.50%	−6.20%	−0.90%	−1.50%
Δ *Outputs and Inputs*												
Δ Total outputs (TO) -successive	–	−34.35%	11.02%	14.33%	28.92%	15.33%	36.70%	35.11%	61.26%	43.13%	14.40%	22.58%
Δ Total inputs (TI) -successive	–	−3.51%	51.39%	14.90%	8.11%	−11.19%	58.80%	14.13%	45.25%	44.57%	26.21%	24.87%
Δ Total outputs (TO)-fixed	–	−34.35%	−27.12%	−16.68%	7.42%	23.89%	69.35%	128.80%	268.98%	428.11%	504.15%	135.25%
Δ Total inputs (TI) -fixed	–	−3.51%	46.09%	67.85%	81.47%	61.17%	155.94%	192.11%	324.30%	513.39%	674.17%	211.30%

Raw productivity=*tfp**=TO/TI, whereas raw total factor productivity change: *tfpch**=percentage change in *tfp** between 2 years=[(*tfp**2/*tfp*1*)−1]*100. Successive *tfpch** measures change the basis year every year, whereas fixed *tfpch** measures fix the basis year at 1989

Table 8 Returns to Scale of REITs in the 1990s

Year	IRS(%)	CRS(%)	DRS(%)
1989	30	24	46
1990	63	19	18
1991	56	13	31
1992	56	7	37
1993	37	5	58
1994	16	6	78
1995	41	11	48
1996	23	8	69
1997	43	7	50
1998	53	9	38
1999	*18*	*3*	*79*
Mean			
89–93[bs]	48	14	38
94–99	32**	7*	60***
89–99	40	10	50

RTS Returns to scale, IRS increasing returns to scale, CRS constant returns to scale, DRS decreasing returns to scale, *bs* basis period (1989–1993)
Returns to scale refer to the increases in output that result from increasing *all* inputs by the same percentage. There are three possible cases: (1) *increasing returns to scale* occur when 1% increase in inputs produces more than 1% increase in outputs; (2) *constant returns to scale* occur when 1% increase in inputs results in exactly 1% increase in outputs; and 3) *decreasing returns to scale* happen when 1% increase in inputs leads to less than 1% increase in outputs. *,**,*** indicate, respectively, significance at the 10%, 5%, and 1% levels between the means of the base period and post-1993 period using non-parametric significance tests

indexes. In general, these results somewhat validate our results in that they are robust and are not just "meaningless" artifacts of our sophisticated technique.[25]

5.2 Further look into scale efficiency developments

So far our results suggest that despite technical regress, the REITs industry achieved significant technical efficiency increases in the 1990s, driven mostly by scale improvements. A scale efficient (*se*) firm will produce where there are constant returns to scale (CRS), i.e., at the bottom of the assumed U-shaped average cost curve. In cases where there are increasing returns to scale (IRS), then efficiency gains can be obtained by expanding production levels. If DRS exist, efficiency gains can be achieved by reducing production levels. Against this backdrop, it is important to closely examine the sources of such scale efficiency gains in REITs (by determining the direction of their scale movements). For this purpose, using the DEA, we computed the returns to scale of the REITs firms during the decade. The results are presented in Table 8.

As discussed before, the trend in the REIT world has been increasing the size of the typical equity REIT. Evidently, in the beginning of the decade, there were only four REITs with equity market capitalization of over $1 billion. However, due to a

[25] For banking firms, Elyasiani et al. (1994), Berger and Mester (1997) and Isik and Hassan (2003c) also show that information contained in efficiency measures closely corresponds to that contained in standard financial ratios.

combination of internal growth, merger activity and the huge amount of capital raised in the second half of the decade, by 2000, there were 44 REITs with equity market caps of more than $1 billion (Block 2002; Ling and Archer 2005). Thus, in retrospect, as the REIT industry grew substantially and registered significant scale efficiencies (as demonstrated by our results), these scale efficiency gains must have occurred by expanding the scale of operations (marching *up* from the IRS portion of the frontier to the CRS portion) rather than downsizing (marching *down* from the DRS portion to the CRS portion). This implies that most of the REITs in the early years of the decade must have experienced IRS in their operations. Our scale results confirm those implications. In 1991, 1992 and 1993, the majority of REITs demonstrated IRS (63%, 56% and 56%, respectively). This means that most REITs were too small to collect the economies of scale and needed to become bigger. The earlier studies that used samples from the beginning years of the decade, such as Bers and Springer (1997, 1998a, b) from 1992–1994, Anderson et al. (2002) from 1992–1996, all observed IRS and economies of scale opportunities in REITs and accordingly suggested sector expansion through organic or external growth. However, our longer data set indicates that those years where scale efficiency benefits could be obtained by just growing size are by-gone and history. Our results suggest that by the end of the decade, 79% of the REITs were in one way or another suffering from DRS, while only 18% showed IRS in their operations.[26] The excessive growth in the late 1990s seems to have forced many REITS to "transgress" the optimum production point and experience diseconomies of scale (DRS), suggesting that REITs may have to shift their business strategies from expansionary policies to efficient internal operations and customer service.[27]

One should, however, be cautious in interpreting the above results concerning the Malmquist indexes and returns to scale measures, as ceteris paribus assumption does not hold. If, for the period after 1993, liberal reforms represented the only change to happen, then we would interpret all changes in operational performance as being the result of these reforms. However, there were many other factors in the broader economy which took place at the same time and these events may have offset or masked the effects of deregulation. In "Section 5.1" above, we tried to trace the impacts of some important macroeconomic factors on the results. Although not perfectly, the design of our analysis mitigates the effects of these factors to some extent. Unlike earlier financial institutions studies (e.g., Grabowski et al. 1994; Zaim 1995; among others), we do not compare the performance of only 2 years, one

[26] We used non-parametric significance tests (based on a binomial distribution) to test if the changes in the numbers in the IRS, CRS or DRS columns are statistically meaningful. The results indicate that both IRS and DRS changes are statistically material.

[27] The dominance of DRS observed here, which confirms the nonexistence of scale economies for REITs, is in line with McIntosh et al. (1991) and Ambrose and Linneman (1998). Furthermore, Topuz et al. (2005) find that the majority (92%) of large REITs experience DRS, suggesting that REITs probably have been experiencing diseconomies of scale with the dramatic and ongoing merger and acquisition activities since 1995. In fact, Bers and Springer (1998a) report that the primary sources of the scale economies are management fees and general administrative expenses, both of which are smaller components of REIT total costs. It may be that little growth in size must have exhausted such small scale economies in the early years of the decade.

representing the pre-liberalization era and other representing the post-liberalization era. In fact, the selection of specific years can bias the empirical results as they may be extremely good or bad years (Isik and Hassan 2003b). Against this backdrop, we use the averages of the years before (4 years) and after 1993 (5 years) to judge the effects of reforms on REITs performance. It may be safe to assume that the impacts of other events will balance each other in a relatively long period.[28]

6 Overall summary and concluding remarks

REITs are real estate securities that sell like a stock on the major exchanges and invest in real estate directly, either through properties or mortgages. With the creation of REITs in 1960, the legislators intended to provide the same opportunities to the average citizen as were available only to the "elite" institutions or wealthy; such as spreading the risk of loss by greater pooling of investments, obtaining the benefits of professional management by real estate experts and sharing in projects that ordinary investors could not undertake individually. Although REITs have been around for more than 40 years, it has only been after 1993 that most investors, especially institutional investors, have really started buying into these relatively new funds. After a very warm reception in the 1960s, investors became disenchanted with the entire industry due to their negative experience with numerous mortgage REIT failures in the 1970s and poor performance in the 1980s. 1993 was the hallmark year that transformed the industry fundamentally.

After 1993, investors poured money into REITs at record levels. Based on NAREIT statistics, REIT market capitalization soared by more than tenfold (from less than $9 billion in 1990 to more than $124 billion in 1999). In parallel, the average asset size of the typical REIT also surged during the decade, from $190 million to $1.7 billion. Although regulatory reforms and subsequent phenomenal growth of the 1990s have important implications for the productivity, efficiency and returns to scale of the REITs industry, the finance literature has not caught up with these developments (Berger and Humphrey 1997). The purpose of this study is to examine the effects of these radical transformations in the business environment of REITs on their managerial and operational performance. After all, if there is a competitive advantage from growth, it should lie with management rather than ownership.

We hypothesize that if the remarkable asset growth of the REITs after 1993 were accomplished with the *same* infrastructure of factor inputs and innovation, one should also observe impressive gains in their productivity, technology and efficiency.

[28] Although introduced in 1999, the REIT Modernization Act (RMA) became effective in 2001, which is out of the scope of this study period. Hence, there are two important regulatory reforms after 1993 to consider (Revenue Reconciliation Act of 1993 and REIT Simplification Act of 1997). Thus, one may argue that it is hard to distinguish their differential impact on REITs' performance. However, we treat 1993 as the year that separates post-deregulation era from pre-deregulation era. Thus, performance difference between these two periods is of main concern for our purpose. Besides, we also test the significance of annual performance difference with respect to the basis year (1989, the representative year of the pre-deregulation era), which could capture the separate effects of these two reforms. We thank our anonymous referee for raising these issues.

On the other hand, if the fast market growth caused REITs outgrow their managerial skills or used more resources, or tolerated managerial inefficiencies by flooding inadequately trained managers with lots of money, then one should expect a deterioration in the productivity and efficiency of these institutions. Furthermore, it is interesting to know if the steady growth and consolidation of the industry during the decade brought about any economies of scale. Utilizing a balanced panel data set of 51 REITs that span the 1989–1999 period, we measure productivity growth of REITs using Malmquist productivity indexes and isolate the contributions of technological change, technical efficiency change and scale change to productivity growth.

Our successive year frontier results suggest that the REIT industry experienced a 2% productivity decline, a 14% technical regress, and a 19% efficiency increase per year during the decade, indicating that the major source of productivity decline in the sector was a downward shift in the production frontier (technical regress) rather than increasing distances of REITs from the frontier (efficiency decrease). One explanation is that the leading REITs on the frontier have failed to improve technically, but the typical REITs exerted substantial efforts to gain efficiency and catch up with the leaders, narrowing the difference between the best-practice and worse-practice REITs. However strong, the efficiency improvements of the average REITS were inadequate to offset the negative impact of technological regress on productivity. When efficiency increases index is decomposed into its components, we observe that managerial efficiency, represented by pure technical efficiency, rose by only 2%, while scale efficiency soared by 17%, implying that the stunning efficiency performance of the period was mostly due to scale improvements rather than managerial improvements. The sub-period results (1994–1999 versus 1989–1993) indicate that although the REITs industry has recorded substantial efficiency increases (both technical and scale) after liberalization, their productivity and technology have not advanced as expected.

Against this backdrop, we also analyzed the returns to scale performance of REITs to determine the nature of their scale adjustments. We found that the majority of REITs were experiencing increasing returns to scale in the beginnings of the decade. Thus, most of the scale efficiency gains of REITs in the 1990s must have resulted from their marching up towards the optimum scale, indicating that their expansionary business strategies either via organic growth or acquisitions were timely given their initial minuscule size. However, by the end of the decade, it appears that the REITS had already exhausted most of the economies of scale opportunities and started to suffer from decreasing returns to scale. One policy implication is that recording efficiency gains by simply growing firm size through acquisitions is over, and REIT managers should begin to turn their focus on “house cleaning” by eliminating redundancies and inefficiencies.

The declining productivity implies that REIT expenses (inputs) must have grown much faster than REIT assets (outputs) during the decade. Our results indeed show that on average total inputs rose by 211%, while outputs rose by 135% as compared to 1989. Further probe into the nature of inputs reveals that the prime cause of the faster rise of inputs is soaring property operating expenses (primarily under management control) rather than financial expenses (primarily market driven and cyclical). This somewhat validates our major findings that impressive efficiency

increases of the decade were mostly due to scale adjustments but not better economy of resources and/or efficient run of the properties by REIT management. Awashed with "hot money" from new investors during the decade, REIT managers may have had the comfort to pay little attention to efficient input utilization and elicited "expense preference behavior". Also, the bullish lending market of the pre-1998–1999 period seems to have failed to exert the required market discipline on REIT managers. As a result, REIT managers have become obsessed with "expanding their balance sheets" and acquiring almost any property that was available at prices (inputs) that have failed to deliver the expected returns (outputs).

Furthermore, being forced to run an enterprise ten times larger due to rapid growth, the current REIT directors might simply have outgrown their existing management skills. Our analysis of returns to scale provides some evidence in this regard. During this period, as most of the REITs, especially the large ones, got bigger, they tended to suffer substantially from diminishing returns to scale. In addition, the substantial contraction in REIT production technology implies that the leading REITs were the ones that were hurt most in the new environment. Since they were the most active in asset expansion, particularly through mergers and acquisitions, it appears that they needed more time to eliminate the redundancies in the combined firm and reduce the cost of expansion. Finally, the technical problems of the industry and its leading firms can be also partly attributed to their relative "youth". It may be that REITs are *still* riding the "learning curve" and accumulating experience to cope with the challenges of the swiftly changing business environment.

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Appendix

Efficiency measures are usually expressed as a percentage by using distance functions. To illustrate these terms, we use Fig. 1. Assume that a firm uses a single input (x) to produce a single output (y) and production technology is one of constant returns to scale (CRS frontier = *R3*). Note that technology *V1* is one of variable returns to scale (VRS frontier); i.e., technology exhibits IRS to the left of *t*, DRS to the right of *t* and CRS at the point *c*. *Technical efficiency* for the firm operating at point *b* will be given by: $te = ab/ad$, which reflects the ability of a firm to achieve maximal output (*d*) from a given input (*a*). Because of imperfect competition, regulatory and market distortions, firms may *not* be operating at the most scale efficient (CRS) production level. Thus, relaxing the assumption of CRS and constructing a production frontier under variable returns to scale (VRS frontier = *V1*), one can compute the technical efficiency devoid of scale effects, which is dubbed *pte*. PTE at point *b* is measured by $pte = ab/ac$. *Scale efficiency* refers to a proportional increase in output generation if the firm can attain the optimum

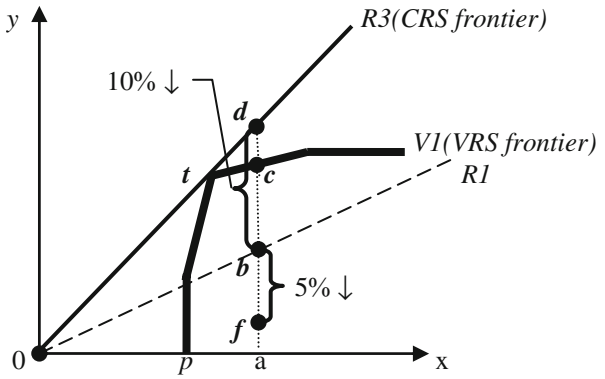

Fig. 1 Definition of Malmquist index measures

production level (point *d*), where there are CRS. Thus, *se* is given by: *se* = *ac*/*ad*. The *te* score is multiplicative, i.e., it is a product of *pte* and *se* scores: *te* = *pte***se*. Obviously, if the firm is fully scale efficient (*se*=1), the distance *cd* disappears and *te* becomes equal to *pte*.

The Malmquist *tfpch* index, however, takes the following general form:

$$tfpch = techch \times effch = techch \times \overbrace{pech \times \sec h}^{effch} \tag{E1}$$

The terms *techch* stands for technological change, *effch* for technical efficiency change, *pech* for pure technical efficiency change and *sech* for scale efficiency change. To understand this decomposition, consider the example in Fig. 1, where the firm located at point *b* moved to point *f* between year *t* and year *t*+1 but the estimated frontiers did not shift upward or downward (the CRS frontier at year *t* and year *t*+1, is represented by R3, and the VRS frontier by *V*1). The subcomponents of the *tfpch* index are given below (where *c* denotes a CRS technology; *v* denotes a VRS technology):

$$techch = \left[\frac{d_t^c(x_{t+1}, y_{t+1})}{d_{t+1}^c(x_{t+1}, y_{t+1})} \times \frac{d_t^c(x_t, y_t)}{d_{t+1}^c(x_t, y_t)}\right]^{0.5} = \left[\frac{af/ad}{af/ad} \times \frac{ab/ad}{ab/ad}\right]^{0.5} \tag{E2}$$

$$effch = \frac{d_{t+1}^c(x_{t+1}, y_{t+1})}{d_t^c(x_t, y_t)} = \frac{af/ad}{ab/ad} \tag{E3}$$

Note that *tfpch*=*techch* * *effch*. By moving from point *b* to point *f*, not only does the firm become less productive (*tfpch*<1) but also less efficient (*effch*<1), *i.e.*, the firm's output level decreases from *b* to *f*, given the same level of input (a), leading to a productivity fall, and the firm's position falls further behind the efficient frontier (R3), leading to an efficiency decrease. In this case, the only reason for the productivity decline is the increased distance of the firm from the efficient frontier (efficiency decrease) rather than technical regress, as the frontier did not shift upward or inward (*techch*=1).

We can further investigate the causes of efficiency decrease by decomposing it into:

$$pech = \frac{d_{t+1}^{v}(x_{t+1}, y_{t+1})}{d_{t}^{v}(x_t, y_t)} = \frac{af/ac}{ab/ac} \tag{E4}$$

$$sech = \frac{d_{t+1}^{c}(x_{\times+1}, y_{t+1})/d_{t+1}^{v}(x_{t+1}, y_{t+1})}{d_{t}^{c}(x_t, y_t)/d_{t}^{v}(x_t, y_t)} = \frac{af/ad}{af/ac} \div \frac{ab/ad}{ab/ac} \tag{E5}$$

The decomposition indicates that the efficiency decrease (*effch*<1) for our firm is driven by decreases both in pure technical efficiency (*pech*<1) and scale efficiency (*sech*<1).

At a glance, our REIT industry analysis produces somewhat a paradoxical result, while the productivity of REITs falls, their efficiency rises. This may indeed occur when (*techch*<1) and (*effch*<1). However, the extent of regress in technology should be greater than the extent of the fall in efficiency. To see this, review once again the firm located at point *b*. By moving to point *f*, we saw that the firm became less productive. Assume that *tfpch*=0.95, i.e., the firm now produces 5% less output with the same level of input (a). Also assume that the CRS_t frontier (R3) shifted downward to CRS_{t+1}(R1), and *techch*=0.90, i.e., technical regress caused leading firms to produce 10% less output from the same amount of input (a). Although both technical regress and efficiency decrease are at play in this example, productivity decline results exclusively from technical regress (10%) as the virtual efficiency improves by 5%. Note that efficiency is measured as the proximity to the frontier. The 5% efficiency decrease is fully offset by the 10% downward shift in the frontier, resulting in net 5% efficiency rise (i.e., the proximity of inefficient firms to the frontier ultimately increases by 5% at the new location, *f*). For this event, the Malmquist indexes would be: $tfpch = [(af/ad)/(ab/ad)] < 1$; $techch = [(af/ad)/(af/ad)^{*}(ab/ad)/(ab/ad)]^{0.5} = 1$;$effch = [(af/ad)/(ab/ad)] > 1$; $pefch = [(af/ac)/(ab/ac)] < 1$; $sech = [(af/ad)/(ab/ac)]/[(af/ac)/(ab/ac)] < 1$

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