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Editorial Staff: Tele. No: 0092 - 42 - 36560969
Telefax: 0092 - 42 - 36560905
E-mail: nina@lahoreschool.edu.pk
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A Decomposition Analysis of Capital Structure: Evidence from Pakistan's Manufacturing Sector

Attiya Yasmin Javid* and Qaisar Imad**

Abstract

This study investigates the determinants of the various components of debt—short- and long-term debt and their categories—in the case of nonfinancial listed firms in Pakistan for the period 2008–10. We make a significant distinction between these determinants depending on the components of debt issued: long-term or short-term forms of debt. Our results show that large firms are more likely to have access to long-term debt borrowing than small firms and that, due to supply constraints, small firms resort to short-term forms of debt. Firms with higher potential for growth prefer using less long-term debt as well as debt with fewer restrictive arrangements in order to become more financially flexible. Firms with sufficient fixed assets can generate external finance more easily and at lower cost by using these assets as collateral, which supports the tradeoff theory. Firms generating high levels of profit, however, may choose to finance their investments using internal resources rather than by raising debt finance, which conforms to the pecking order theory. Our results also confirm the presence of the inertia effect and industry-specific effects, and are robust to alternative estimation techniques.

Keywords: Long-term debt, short-term debt, growth, firm size, profitability, Pakistan.

JEL Classification: G32, G15, F23.

1. Introduction

The behavior of corporations in making capital structure decisions is of considerable interest to financial economists. A firm's capital structure comprises different components of debt and equity—a mix of financing that maximizes returns and minimizes risk is known as an optimal capital structure. Capital structure policy, therefore, involves identifying the different factors that determine an optimal capital structure, and entails

* Professor of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad, Pakistan.
** Assistant Treasury Officer, Finance Department, Government of Khyber Pukhtunkhwa, Pakistan.

making tradeoffs between risk and returns. High levels of debt financing may increase expected returns but they also carry a high risk of default on the repayment of debt.

Of the two schools of thought on capital structure, the first argues that there can be an optimal capital structure while the second, led by Modigliani and Miller (1958), argues the opposite. The first school holds that a firm can mix its debt and equity in a proportion that minimizes risk and maximizes the firm's returns and value. It proposes that firms should consider various factors when deciding on a specific capital structure, i.e., the relevance theory of capital structure. The second school supports the idea that different levels of capital structure offer the same level of risk and return, i.e., that capital structure does not matter and should not be considered as the firm's value is determined by its underlying investment decisions (Brealey & Myers, 1996). The theory of the irrelevance of capital structure holds on the basis of certain assumptions, e.g., no transaction costs, no taxes, symmetric information, and no bankruptcy cost. When these assumptions do not hold, capital structure decisions become relevant in financing decisions.

Since Modigliani and Miller's (1958) influential study on the irrelevance of capital structure in investment decisions, a large body of theoretical literature has developed capital structure models under different assumptions. Some theories are based on traditional determinants such as tax advantage and the bankruptcy cost of debt, e.g., the tradeoff theory, while others apply modern financial economics and use an asymmetric information or game theory framework in which debt or equity is used as a signaling tool or strategy choice.

Theories that have been widely tested empirically include the tradeoff theory, pecking order theory, agency cost theory, and signaling information (for an excellent review of the literature on capital structure, see Frank & Goyal, 2003; Harris & Raviv, 1990). In addition, firms may find that the availability of external financing is restrictive and that the cost of different types of external finance may vary. Firms will try to select levels of debt and equity in order to reach an optimal capital structure in such an imperfect environment. However, there is little consensus on how firms select their capital structure, and the factors that influence components of capital structure are still largely unexplored.

Our main aim is to analyze the impact of selected factors—growth or investment opportunities, firm size, profitability, and tangibility—on the capital structure of firms listed on the Karachi Stock Exchange (KSE) (see

Harris & Raviv, 1990; Rajan & Zingales, 1995). For a more in-depth analysis of the determinants of capital structure, we divide debt element into short- and long-term debt and their categories to indicate the sensitivity of the above factors to whichever debt component has been selected by the firm. While both short- and long-term debt components are used in corporate financial decisions, our analysis is based solely on long-term forms of debt, which provides a focused insight into the mechanics that operate Pakistan's financial and corporate sectors.

We attempt to provide empirical justifications for some of the theories on capital structure in Pakistan's context. In this regard, the study is an important contribution to the literature because it tries to identify the presence of the inertia effect in leverage decisions by applying dynamic panel models. We assess cross-industry differences in leverage choices by introducing industry dummies into leverage models. Above all, we investigate whether, in Pakistani firms, the determinants of the level of debt differ significantly depending on which element of debt is being examined.

The study is organized as follows. Section 2 reviews the empirical literature on capital structure. Section 3 discusses the methodology and data used. Our empirical results are presented in Section 4, and Section 5 concludes the study.

2. A Review of the Literature

This section reviews briefly several key theories of capital structure, and their results when empirically tested: (i) the pecking order theory, (ii) the static tradeoff hypothesis, and (iii) agency theory. It then summarizes some of the literature on the determinants of capital structure.

2.1. Theories of Capital Structure

The pecking order model tested by Myers and Majluf (1984) shows that the use of private information is the only source through which firm managers seek to issue risky and overpriced securities, as a result of which an outside investor will demand a higher rate of return on equity than on debt. Myers (1977) has argued that the pecking order model does not explain firms' dividends distribution. However, when firms choose to pay dividends for other reasons, pecking order choices should affect dividend decisions. This is explained by the argument that it is not desirable for firms to finance investment with new risky securities and dividends are less attractive for firms with less profitable assets with large current and future expected investments and high debt. However, if external financing becomes necessary when internally generated funds are not enough to pay dividends or to finance growth-oriented investment, the model hypothesizes that firms with a low risk of financial distress will issue direct conventional debt; firms with a medium risk of financial distress will issue hybrid securities—such as convertible debt or preference shares; and firms that are high-risk due to financial distress will issue external equity.

The pecking order theory suggests that firms use a ranked structure to select sources of external financing (as mentioned above) only because the amount of mispricing and loss of wealth to shareholders both depend on the type of security issued. The amount of loss is lowest for debt and highest for external equity because new information affects the value of a security. The new information will have the least effect on the value of debt because debt holders have first priority on a firm's income and assets. However, new information will have the most effect on the value of equity because equity holders have a claim on the firm's residual income and assets.

Additionally, the pecking order theory postulates that debt increases when investment exceeds retained earnings and decreases otherwise. In this context, Fama and French (2002) empirically test and compare its hypothesis with that of the tradeoff model. Their results suggest that more profitable firms are less levered, which is consistent with the pecking order model. They also show that firms with greater investment opportunities are less levered, as postulated by the tradeoff theory. Myers (1977) suggests that, according to the pecking order theory, firms do not have debt targets; rather, their current and expected future financing costs set desired targets that can be modified. Firms expecting more investment opportunities may have less debt, but this may change over time when, for example, net cash flows are sucked up by debt.

The static tradeoff theory has been extensively tested empirically around the argument that the expected increase in tax-shield benefits from issuing debt finance may neutralize the cost of financial distress, such as cash flow volatility, the cost of expected bankruptcy in the case of default, and the threat of lack of cash. The theory suggests that the maximum debt is determined by equating the corporate tax-saving advantage of debt with the deadweight cost of bankruptcy (Barclay & Smith, 1999; Bradley, Jarrell, & Kim, 1984; DeAngelo & Masulis, 1980; Myers, 1977). Miller (1977) and Graham and Harvey (2001) argue that the tax saving is large and sure while the bankruptcy cost seems to be very small, indicating that firms should have more debt compared to their leverage level. Further, Myers (1977) has argued that this theory should provide an important insight into optimum capital structure decisions in terms of tax shields, although he finds that the tax effects are very small when tested empirically.

From the standpoint of the static tradeoff theory, firms that are more profitable should issue more debt because they have more profits to protect from taxation. However, some studies have criticized this argument as higher profitability means lower expected costs of financial distress and, moreover, firms use more debt relative to book assets (Fama & French, 2002; Myers, 1984; Titman & Wessels; 1988). The tradeoff theory postulates that larger and more mature firms use more debt while managers are agents of shareholders and their interests may be in conflict with those of shareholders such that debt is considered a controlling device. Bankruptcy is costly for managers since they can be displaced and thus lose their job benefits. Therefore, debt can mitigate agency conflict between shareholders and managers, an idea put forward by Jensen and Meckling (1976), Jensen (1986), and Hart and Moore (1988). There may also be agency conflicts between shareholders and debt-holders (Myers, 1977).

Agency theory provides another explanation for why debt can be used as a controlling mechanism in agency costs between managers and shareholders—creditors may act as monitors of managers' investment decisions. However, these capital structure decisions do not necessarily control agency costs—the agency cost of debt comprises the problem of excessive dividends, issuance of senior ranking debt, asset substitution, and underinvestment (Smith & Warner, 1979), which measure the possibility of bankruptcy and restructuring the debt and the cost of monitoring debt agreement. A firm with higher debt financing is more likely to have an agency cost of debt.

Firm managers are owners who try and transfer wealth from bondholders to shareholders; in this situation, the use of incentive contracts, such as options, is best suited to mitigating the problem. The empirical literature shows that the more profitable firms issue more debt to control managerial self-interest behavior. Agency theory suggests that growth firms should have less debt while firms that have more future profitable investment prospects need less debt. Regulated firms have fewer agency problems so that debt is not needed to discipline their management.

2.2. Determinants of Capital Structure

A large body of empirical research attempts to identify the most significant determinants of optimal structure but the findings differ due to variations in context and the components of capital structure that are considered. Rajan and Zingales (1995) analyze the capital structure of nonfinancial firms in the G-7 countries, and identify a positive relationship between tangibility and leverage; the market-to-book value and profitability are negatively related to debt. Bevan and Danbolt (2000) examine the capital structure of 822 British companies, and find a positive relationship between the market-to-book ratio and nonequity liabilities-to-total assets ratio, but a negative relationship between the book value of adjusted debt-to-adjusted capital ratio. The market-to-book ratio has no impact on the book values of total debt-to-total assets ratio and debt-to-capital ratio, while the market-to-book ratio has a significant negative relationship with all forms of the market values of capital structure. Bevan and Danbolt also find that firm size has a positive relationship with the book values of all forms of capital structure, while profitability and tangibility have a negative relationship with both the book and market values of all measures of capital structure. They conclude that tangibility has a significant positive relationship with the book and market values of debt-to-total asset ratio and adjusted debt-to-adjusted capital ratio, but no significant relationship with the debt-to-capital ratio.

The empirical literature on emerging markets shows that, as with developing markets, firm size has a mixed relationship with leverage. Oyesola (2007) and Chen (2004) conclude that firm size is positively related to total debt and short-term debt, but negatively related to long-term debt. Suhaila and Wan Mahmood (2008), Ramlall (2009), Chen (2004), and Baral (2004) find that there is a negative association between firm size and total debt, while Teker, Tasseven and Tukel (2009) show that firm size and the ratio of depreciation to operating profit has no relationship with capital structure.

Profitable firms do not rely much on external debt (Chen, 2004; Liu & Ren, 2009; Oyesola, 2007) and vice versa, and firms with a high tangibility ratio can easily access debt by offering tangible securities to their creditors (Liu & Ren, 2009; Oyesola, 2007; Suhaila & Wan Mahmood, 2008). However, Ramlall (2009) and Teker, Tasseven, and Tukel (2009) put forward slightly different results, showing that profitability is positively related only to long-term liabilities and short-term loans, and negatively related to the other components of capital structure.

Tangibility impacts capital structure negatively in the case of total liabilities and short-term liabilities, whereas it affects tangibility positively in the case of long-term liabilities, long- and short-term leases, long- and short-term loans, and long-term debt. Serrasqueiro and Nunes

(2008) find that tangibility is not a significant determinant of capital structure. The nondebt tax shield and dividends have a positive relationship with leverage (Oyesola, 2007); the nondebt tax shield is positively related to the short-term debt ratio but negatively related to the long-term debt ratio (Chen, 2004; Ramlall, 2009; Serrasqueiro & Nunes, 2008; Suhaila & Wan Mahmood, 2008). Growth opportunities have a weak relationship with capital structure (Liu & Ren, 2009; Oyesola, 2007; Serrasqueiro & Nunes, 2008; Suhaila & Wan Mahmood, 2008), although Chen (2004) documents a positive relationship and Baral (2004) identifies a negative relationship between the two.

In analyzing other determinants of capital structure, Suhaila and Wan Mahmood (2008) find a negative relationship between the liquidity (quick ratio) and interest coverage ratio (the ratio of net income before taxes and dividends to interest expenses) and debt. However, there is a weak but statistically significant relationship between income variability and capital structure. Chen (2004) reports that the cost of financial distress as represented by a firm's earning volatility has a very weak relationship with capital structure. Baral (2004) concludes that business risk, the dividend payout ratio, debt service capacity, and degree of operating leverage, are minor contributors to leverage. Finally, Serrasqueiro and Nunes (2008) find that the level of risk is not a significant determinant of capital structure.

2.3. Capital structure in the Pakistani firm context

The research on the Pakistani market's capital structure is very limited. Ilyas (2005), Shah and Hijazi (2004), and Shah and Khan (2007) have examined the capital structure of nonfinancial firms listed on the KSE. Shah and Khan reveal the existence of a positive relationship between tangibility and capital structure. Firm growth and profitability are negative but not statistically significant contributors to capital structure, while firm size has a very weak and statistically insignificant impact on capital structure. In addition, earning volatility and nondebt tax shield have no relationship with capital structure. Shah and Hijazi show that tangibility has no impact on, but that firm size has a positive relationship with leverage while growth and profitability have a negative relationship.

Ilyas (2005) points out that firms' profitability has a negative relationship with leverage, as do size and growth. The study's results show that there is a positive relationship between the nondebt tax shield and leverage, but that this relationship and the degree of financial leverage has a negative relationship with capital structure. Rafiq, Iqbal, and Atiq (2008) investigate the determinants of capital structure for Pakistan's chemical sector for the period 1993–2004, and conclude that firm size, profitability, income variations, nondebt tax shield, and growth are the important determinants of capital structure in that sector.

Cheema, Bari, and Siddique (2003) summarize the country's corporate growth history, providing an overview of the ownership and state of the financial market and its dynamics. They highlight the salient features of the ownership structure of Pakistan's top 40 listed companies. The country's main companies are family-controlled business groups, followed by the state, and affiliates of multinational corporations (Cheema et al., 2003; Javid & Iqbal, 2008, 2010). This concentration of ownership on one hand and underdevelopment of the financial market to provide external finance on the other pushes firms to rely on retained earnings or on borrowing from the informal sector (Javid & Iqbal, 2007).

The energy and chemicals sector rely on issuing equity for external financing and on short-term debt. Booth, Aivazian, Demirgüç-Kunt, and Maksmivoc (2001) point out that the use of short-term financing is greater than that of long-term financing in developing countries (including in Pakistan). It would be interesting to find out whether or not different categories of debt are affected by different factors in the case of Pakistan's manufacturing sector.

3. Methodology and Data

Using panel data estimation techniques, this study investigates the determinants of capital structure and its components for 77 nonfinancial firms listed on the KSE for the period 2008-10. We extend the methodology suggested by Rajan and Zingales (1995), who highlight the contribution of four factors in determining debt decisions at the firm level (in their case, for G-7 countries using a cross-section analysis for 1991): (i) market-to-book ratio, firm size, profitability, and tangibility. Our study includes different components of leverage and examines the effect of these traditionally selected determinants on those components. This section describes the dataset, and discusses the rationale for the various dependent and independent variables used and the manner in which they are calculated.

3.1. Data and Sample

The data for this study has been taken from annual reports of nonfinancial firms listed on the KSE. The sample comprises 77 of the KSE's listed nonfinancial firms[1] for the period 2008–2010. These firms have been selected based on the criteria that they are representative of each sector, and were active and continuously listed during the period of analysis. The firms' annual reports were retrieved from their official websites. The study has also used the *Business Recorder*'s website for firms' average stock prices in order to calculate their market value.

This section describes the sets of dependent and explanatory variables and their construction, the selection of which draws on the theoretical literature on capital structure in financial economics and the empirical evidence discussed in Section 2 (see Bevan & Danbolt, 2000; Harris & Raviv, 1990; Rajan & Zingales, 1995; Shah & Hijazi, 2004).

3.2. Dependent Variables

The leverage or gearing ratio is defined as the debt-to-equity ratio. Alternative measures of leverage are determined by different firm-specific factors. To examine the sensitivity of the definition of the leverage variable, it is important, therefore, that this variable be constructed by alternative definitions of leverage suggested in the empirical literature (Rajan & Zingales, 1995). Decomposing the individual firm's leverage would give more insight into the factors that influence the components of leverage and the extent of their influence in determining corporate financial structure. Thus, we decompose debt into four components at book value.[2]

Nonequity liabilities-to-total assets (LV_1) is defined as the ratio of long-term debt (*LTD*) plus trade credit and equivalent (*TTCE*) to total assets (*TA*).[3] This measure is used as a proxy for the firm's liquidation value. However, Rajan and Zingales (1995) argue that this measure may be somewhat inflated because trade credit and equivalent belong to financing transactions rather than assets.

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[1] These firms constituted 80 percent of the KSE's market capitalization in 2007. Note that we have included nonfinancial firms because there is a difference between their capital structure and that of financial firms, and a combined analysis of both might not present a true picture.

[2] The debt-to-equity ratio based on book values reflects firms' past financial choices, whereas the ratio's market value indicates their future choices (Frank & Goyal, 2003). Fama and French (2002) point out some inconsistencies arising from the use of two different debt ratios: they observe that both the pecking order theory and static tradeoff theory apply to the book value of the ratio, and there are doubts if the predictions can be extended to the debt market value.

[3] At book value, $DE_1 = (TD + TTEC)/TA$.

Debt-to-total assets (*LV_2*) is the simple ratio of long-term debt at book value (*LTD*) to total assets (*TA*).[4]

Debt-to-capital (*LV_3*) is obtained by dividing long-term debt (*LTD*) by capital, where capital is calculated as long-term debt plus equity capital and reserves (*ECR*) and preference shares (*PS*).[5]

Adjusted debt-to-adjusted capital (*LV_4*): This ratio is obtained by dividing adjusted debt by adjusted capital. Adjusted debt is calculated by deducting total cash and equivalents (*TCE*) and marketable securities (*MS*) from long-term debt. Similarly, the book value of adjusted debt is calculated as the book value of long-term debt and capital plus provision (*PROV*) and deferred taxation (*DTAX*) less intangible assets (*INTANG*).[6]

These four components of the debt-to-equity ratio capture the key elements of capital structure. Therefore, the study focuses on the above four measures of leverage and examines their determinants.

3.3. Independent Variables

Although the factors determining capital structure components can be controversial (see Harris & Raviv, 1990; Titman & Wessels, 1988), we follow Rajan and Zingales (1995) and adopt four independent variables that are traditionally considered key.

3.3.1. Growth

The market-to-book ratio is used to capture the growth opportunities that exist for the firm. A negative relationship is expected to exist between growth potential and the level of debt. This is consistent with the agency theory proposed by Jensen and Meckling (1976) and also with Myers's (1977) argument concerning information asymmetry, i.e., that firms with high levels of debt may have the possibility of not exercising care with good investment opportunities. Therefore, firms with large investment opportunities would likely have low debt-to-equity ratios. Moreover, as growth opportunities do not promise immediate revenue, firms may be unwilling to take on large contractual liabilities at the time.

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[4] $DE_2 = TD//TA$

[5] $DE_3 = TD//(TD + TCR + PS)$

[6] $DE_4 = (TD – TCE – MS)//(TD + ECR + PS + PROV + DTAX – INTANG)$

Growth opportunities are, essentially, intangible and, therefore, may be considered limited collateral value or liquidation value to firms. Those with greater growth potential may not be interested in seeking debt or in finding additional debt-financing sources. However, the empirical evidence regarding the relationship between debt and growth opportunities is inconclusive. Many studies find a negative relationship between the two (see Barclay, Smith, & Watts, 1995; Chung, 1993; Rafiq et al., 2008; Rajan & Zingales, 1995; Shah & Hijazi, 2004; Titman & Wessels, 1988), which bears out the argument of Jensen and Meckling (1976) and Myers (1977), and is consistent with the view that firms with high levels of growth opportunity can be expected to have low levels of debt.

Kester (1986) does not find any evidence for the expected negative relationship between growth opportunities and debt decisions, while Delcoure (2007) and Rafiq et al. (2008) come up with a positive relationship between the growth and leverage. It is expected that firms with more growth opportunities have higher leverage. Based on this argument, our first hypothesis is:

There is a positive relationship between growth opportunities and leverage.

In this study, the market-to-book ratio is used as a measure for firms' growth opportunities or investment opportunities.[7] The market-to-book ratio (*growth*) ratio is calculated as the book value of total assets less the book value of equity plus the market value of equity divided by the book value of total assets.

3.3.2. Firm Size

The logarithmic transformation of sales is used as a measure for firm size in the theoretical literature; there is no explanation to support how the size of the firm affects its debt decisions. The inconclusive relationship between size and debt may be accounted for by the nature of large firms who leave fewer chances to fail, making it possible to measure size as the logarithm of net sales, which, if inverted, can be used as the probability of bankruptcy (Rajan & Zingales, 1995). Larger firms are more likely to have a credit rating and thus have available to them nonbank debt financing, which is usually unavailable to smaller firms. This would imply a positive relationship between firm size and leverage (Titman & Wessels, 1988).

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[7] Firms' growth opportunities are measured by different proxies in the empirical literature, e.g., the market-to-book value of equity, research-expenditure-to-total-sales measure, and annual percentage increase in total assets (Titman & Wessels, 1988).

The opposing view is that there is less asymmetric information about larger firms, reducing the chances of the undervaluation of new equity issues, and encouraging large firms to use equity financing. This means that there should be a negative relationship between size and leverage (Frank & Goyal, 2003; Rajan & Zingales, 1995). The empirical evidence with regard to the relationship between size and debt is inconclusive: Rajan and Zingales (1995), Bevan and Danbolt (2000), Shah and Hijazi (2004), and Rafiq et al. (2008) find firm size to be significantly and positively related to leverage. Size is expected to have a positive coefficient since larger, more diversified, firms are likely to have lower bankruptcy, and be able to sustain a higher level of debt (Agrawala & Nagarajan, 1990; Ferri & Jones 1979; Scott & Martin, 1975). Larger firms are expected to have more leverage. This leads us to our second hypothesis:

There is a positive relationship between the size and leverage of a firm.

Firm size (*size*) is measured by taking the natural log of its sales.

3.3.3. Profitability

There are mixed opinions about a firm's profitability and its debt decisions. The supply-side argument suggests that the more profitable firms would have more debt available to them, and that the demand for debt is negatively associated with profitability. Stiglitz and Weiss (1981) argue that an information asymmetry prevents lenders from distinguishing between good and bad risks ex ante and that a variable interest rate cannot be charged depending on their risk type. In this case, creditors would charge an increased interest rate, which would generate the problem of adverse selection since low risks would quit the market due to the high cost of borrowing. Therefore, firms will tend to favor internal to external sources of finances due to this information asymmetry.

Modigliani and Miller (1963) suggest that, as taxes are paid after interest payments, firms may favor debt over equity, and the more profitable firms will select high levels of debt to gain more favorable tax shields. However, Miller (1977) has later criticized his and Modigliani's (1963) arguments by taking account of the effect of personal taxation. Moreover, DeAngelo and Masulis (1980) argue that some firms have other tax shields such as depreciation, and may not find interest tax shields as attractive.

The pecking order argument presented by Myers and Majluf (1984) and Myers (1984) is that information asymmetry pushes firms to favor internal over external capital sources, which is why firms that are more profitable will choose to finance investments through retained earnings rather than through external debt. Toy, Stonehill, Remmers, Wright, and Beekhuisen (1974), Kester (1986), Titman and Wessels (1988), Rajan and Zingales (1995), Tong and Green (2005), and Rafiq et al. (2008) also support the negative association between profitability and debt in line with the pecking order theory. Thus, the more profitable firms are expected to have less leverage. Our third hypothesis, therefore, is:

There is a negative relationship between the profits and leverage of a firm.

The firm's profitability (*profit*) is obtained by dividing its earnings before interest and taxes (EBIT) by its total assets.

3.3.4. Tangibility of Assets

The more fixed assets a firm owns, the better its chances are of easily obtaining external financing at a low cost since it can use these assets as collateral to secure debt (Rajan & Zingales, 1995). Bradley et al. (1984), Titman and Wessels (1988), and Rajan and Zingales provide evidence of a positive relationship between debt and asset tangibility. The static tradeoff approach also suggests that firms with greater fixed assets can obtain more external debt by using these assets as collateral.

The pecking order theory, however, suggests that firms with low levels of fixed assets will also face problems of information asymmetry, pushing them to raise more debt rather than equity since they can only issue equity if it is underpriced (Harris & Raviv, 1990). Contrary to this argument, large firms have greater fixed assets and are in a better position to issue equity at a fair price. Therefore, they do not need debt to finance new investment. It is expected that firms with a higher percentage of fixed assets will have higher debt ratios. Thus, our fourth hypothesis is:

There is a positive relationship between asset tangibility and firm leverage.

We measure tangibility as the ratio of fixed assets to total assets.

The determinants of leverage and its four components are described by equation (1) given below, which follows Rajan and Zingales (1995) and Bevan and Danbolt (2000).

$$Lev_{it} = \beta_0 + \beta_1 Growth_{it} + \beta_2 \mathrm{Pr}ofit_{it} + \beta_3 Size_{it} + \beta_4 Tang_{it} + \varepsilon_{it} \qquad (1)$$

LEV_{it} represents leverage or gearing ratio and various components of leverage, which are explained by the following factors: Growth ($growth_{it}$), size ($size_{it}$), profitability ($profit_{it}$), and tangibility ($tang_{it}$). These variables are measured on the basis of their book values taken from the sampled firms' financial statements.

3.4. Estimation Technique

In the first stage, we apply a panel data analysis technique to examine the extended leverage models, which will allow us to capture firm heterogeneity (if any) over time. Firm-specific effects are not taken into account in the pooled ordinary least squares (OLS) estimation.[8] Making the empirical model a more general panel data equation and using the set of explanatory variables—growth, size, profitability, and tangibility—a more general, unrestricted, equation would be written as

$$Lev_{it} = \beta_0 + \mu_i + \lambda_t + \beta_1 Growth_{it} + \beta_2 \Pr ofit_{it} + \beta_3 Size_{it} + \beta_4 Tang_{it} + \varepsilon_{it} \qquad (2)$$

The intercept has three parts: β_0, which is common to all firms and all time periods; μ_i, which represents firm-specific intercepts; and λ_t, which refers to time-specific intercepts. The term μ_i represents those unobservable effects that are specific to the firm but common to all time periods, λ_t represents those effects that are specific to particular time periods but common to all firms, β_0 is the mean of all these unobservable effects, and ε_{it} is the error term representing all those unobservable effects that vary both over time and across cross-section units. The βs are slope parameters, which we assume are constant over time as well as across firms and industries.

In the second stage, we estimate a series of dynamic panel leverage models to find out whether previous debt decisions affect firms' current debt choices. Finally, we introduce industry-specific dummies into the model to capture any cross-industry differences.

4. Empirical Results

Our panel data analysis estimates the determinants of four leverage components for 77 firms from 2008 to 2010. Table A1 in the Appendix gives summary statistics on the four components and four determinants of leverage, and the correlation matrix is presented in Table A2.

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[8] Firm-specific effects are omitted under pooled OLS estimation. In such a case, if the unobservable individual-specific effects are correlated with the explanatory variables, then OLS estimates will be biased (Hsiao, 2003).

Before carrying out the panel estimations, it is necessary to examine the data and choose an appropriate estimation technique. Important issues to address are whether the data is stationary or has a unit root; whether individual effects exist, or if the model should estimate a pooled equation with a common intercept and slopes. If there are individual effects, we need to determine if they are period-specific or cross-section-specific or both, and if the unobserved individual effects are fixed constant or randomly distributed independent of the explanatory variables. We also need to resolve any multicollinearity, autocorrelation, or heteroscedasticity.

The time period under study is short (three years) compared to the cross-section unit (77) so that a unit root test is not required. We begin by testing for individual effects and two-way fixed effects: Cross-section and time series are estimated first, followed by period-specific effects alone, cross-section-specific effects alone, and estimation with the application of a common intercept. The analysis consists of four models based on four components of leverage to investigate its determinants.

4.1. Test for Data and Models

To test for individual effects, the following three types of restrictions can be imposed on the above, unrestricted, specification of the models given in equation (2), i.e., to consider only time-specific effects and assume that there are no cross-section-specific effects and test the following hypothesis:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots = \mu_N = 0$$

If the F-test with $N-1$ and $N(T-1)-2K$ degrees of freedom is significant, the null hypothesis will be rejected and we will have to estimate a model with cross-section-specific terms. The second restriction that can be imposed is to treat time-specific effects as equal to 0, and consider a model with only cross-section-specific effects and test the following hypothesis:

$$H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \ldots = \lambda_T$$

If the F-test with $T-1$ and $N(T-1)-2K$ degrees of freedom is significant, the null hypothesis will be rejected and we will have to consider time-specific effects in our estimation model. However, if the F-statistic appears to be insignificant, then time-specific effects can be ignored. The final restriction is to treat the model as a common effects model with neither time- nor cross-section-specific effects and test the following hypothesis:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = ... = \mu_N = 0, \lambda_1 = \lambda_2 = \lambda_3 = ... = \lambda_T = 0$$

If the F-test with $(N-1)+(T-1)$ and $N(T-1)-2K$ degrees of freedom is significant, the null hypothesis can be rejected and the common effects model would be an incorrect choice.

In order to estimate individual effects, we first estimate two-way fixed effects followed by period-specific effects alone, cross-section-specific effects alone, and estimation with a common intercept. The results of the redundant fixed effects are presented in Table 1.

Table 1: Individual effects test

Effects test	Statistic	d.f.	Prob.	Conclusion
Cross-section F-statistic	63.13	(76, 148)	0.00	Reject H_0 of redundancy
Period F-statistic	6.46	(2, 148)	0.00	Reject H_0 of redundancy
Cross-section/Period F statistic	61.61	(78, 148)	0.00	Reject H_0 of redundancy
Cross-section F-statistic	37.24	(76, 148)	0.00	Reject H_0 of redundancy
Period F-statistic	3.78	(2, 148)	0.00	Reject H_0 of redundancy
Cross-section/period F statistic	36.59	(78, 148)	0.00	Reject H_0 of redundancy
Cross-section F-statistic	87.54	(76, 148)	0.00	Reject H_0 of redundancy
Period F-statistic	4.42	(2, 148)	0.00	Reject H_0 of redundancy
Cross-section/period F statistic	85.54	(78, 148)	0.00	Reject H_0 of redundancy
Cross-section F-statistic	79.58	(76, 148)	0.00	Reject H_0 of redundancy
Period F-statistic	6.61	(2, 148)	0.00	Reject H_0 of redundancy
Cross-section/period F statistic	77.76	(78, 148)	0.00	Reject H_0 of redundancy

Source: Authors' calculations.

Both the F-test and the likelihood function (chi-square test)[9] indicate the presence of cross-section fixed effects and period effects. Thereafter, separate tests are conducted. In one case, the unrestricted model is that with only cross-section fixed effects; in the second case, the unrestricted model is with only period effects. The results strongly suggest using a model with only cross-section effects and, therefore, we proceed with a model that has cross-section-specific but no period-specific effects.

[9] The chi-square tests (not reported here) also support the existence of cross-section-specific and time-specific effects.

Having decided to estimate a model with cross-section-specific unobservable effects, our next task is to determine whether these effects are fixed constant correlated with the other explanatory variables (a fixed effects model) or randomly distributed independent of the explanatory variables (a random effects model). In this analysis, the cross-section units are larger than the time period, so care is taken when deciding between a fixed effects and random effects model.[10]

The Hausman (1978) test is used to choose between a fixed effects model and a random effects model. The null hypothesis of the Hausman test states that there is no significant difference between the coefficients of fixed and random effects estimators.[11] Rejecting the null hypothesis would imply that at least some of the explanatory variables are correlated with the individual-specific effects. To perform the Hausman test, a random effects specification is estimated and the null hypothesis of independent individual effects tested using chi-square statistics. The results of this test are presented in Table 4, and indicate that the null hypothesis is rejected if the p-value is less than 0.05—we therefore estimate a fixed effects model. If the Hausman specification test had generated a p-value greater than 0.05, then the null hypothesis would have been accepted, proposing that a random effects model was more suitable.

As regards multicollinearity, the results of the correlation matrix (Table A2 in the Appendix) indicate that the values of all the correlation coefficients between the model's explanatory variables are not very high. The coefficient covariance matrix given in Table A3 in the Appendix clearly indicates that there is no significant relation between the coefficients because the coefficient of covariance between most of the variables is small.

The White heteroscedasticity test is applied before final estimation to check for heteroscedasticity, first, by estimating a fixed effects model,

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[10] With a finite time period and large cross-section units as in this analysis, there is much difference in the estimated parameters of fixed or random effects models compared to cases where the time series is large and the two models give approximately the same results (Hsiao, 2003).

[11] Fixed effects estimators are consistent if the cross-section-specific effects are correlated with the explanatory variables and the random effects are inconsistent and biased. But the random effects are consistent and the fixed effects are inconsistent if the individual-specific effects are independently and randomly distributed of the explanatory variables. Thus, the key factor to consider is whether or not the individual effects are correlated with the explanatory variables. The chi-square test for the difference in estimates is

$$\chi^2_{df} = \left(\hat{\beta}_{FE} - \hat{\beta}_{RE} \right)' \left[\operatorname{var}(\hat{\beta}_{FE}) - \operatorname{var}(\hat{\beta}_{RE}) \right]^{-1} \left(\hat{\beta}_{FE} - \hat{\beta}_{RE} \right).$$

and, then, using the results to reject the null hypothesis of homoscedasticity. Therefore, in the final estimation, the problem of heteroscedasticity will have to be taken into account by estimating the White heteroscedasticity of the adjusted covariance matrix.

4.2. Results of Panel Data Analysis

We begin the panel data analysis by examining the effects of four factors in determining the four types of components of leverage. The results for four simple leverage models given in equation (2) are presented in Table 2 below.

Table 2: Determinants of capital structure components (fixed effects model)

	Nonequity liabilities-to-total assets	Debt-to-total assets	Debt-to-capital	Adjusted debt-to-adjusted capital
Variable	**Model I**	**Model 2**	**Model 3**	**Model 4**
Growth	–0.03	–0.03*	–0.08*	0.09
	(–0.91)	(–2.41)	(–6.40)	(0.73)
Size	0.11*	0.05*	0.05**	0.02*
	(8.45)	(8.47)	(1.88)	(2.79)
Profitability	–0.10*	–0.03**	–0.10*	0.18*
	(–15.05)	(–3.05)	(–2.54)	(2.06)
Tangibility	0.52*	0.56*	0.56*	0.50*
	(10.37)	(15.31)	(10.31)	(5.48)
C	–0.52*	0.44*	–0.20	–0.03
	(2.39)	(–3.46)	(0.82)	(–0.79)
Hausman	6.43	8.23	5.66	16.69
(p-value)	(0.15)	(0.08)	(0.03)	(0.00)
R^2	0.67	0.68	0.62	0.34

Note: The covariance matrix is White heteroscedastic-adjusted; t-values are given in parentheses below coefficients. Asterisk(s) * and ** indicate significance at 1 and 5 percent, respectively.
Source: Authors' calculations.

The results of the Hausman specification test in Table 2 indicate that the fixed effects model best fits the data in all categories of leverage. The regression results for the nonequity liabilities-to-total assets ratio show that growth opportunities are not related to short-term leverage. Profitability has a negative relationship with the nonequity liabilities-to-total assets ratio. Tangibility and firm size both have a strong, positive, and statistically significant relationship with the dependent variable. The results also imply that the more profitable firms use less debt, especially short-term trade credit, since this debt ratio is adjusted to short-term trade credit.

The results for the determinants of debt-to-total assets and debt-to-capital are similar: Growing and profitable firms have less leverage whereas larger firms with greater tangible assets use more debt. The adjusted debt-to-adjusted capital ratio has no relationship with growth opportunities, size, or profitability, while tangibility and size have a strong, positive relationship with this category of leverage. The adjusted debt-to-adjusted capital ratio has a negative relationship with growth opportunities, size, and profitability, while tangibility and size have a strong positive relationship with the dependent variable.

The first hypothesis is not borne out by all the components of debt because growth opportunities are not positively linked to leverage. Earlier studies have also shown inconclusive evidence in this regard. Hijazi and Tariq (2006) and Rafiq et al. (2008) find a positive relationship between growth and leverage, whereas Shah and Hijazi (2004) find a negative relationship. The hypothesis that the more profitable firms use less leverage is confirmed by the first three categories of debt with the exception of the adjusted debt-to-adjusted capital ratio. This result provides empirical evidence in support of the pecking order hypothesis—that firms prefer to finance their operations through internal sources, followed by external debt and equity financing—and Shah and Hijazi (2004), Hijazi and Tariq (2006), and Rafiq et al. (2008) conclude the same.

The hypotheses that firm size and asset tangibility are positively associated with leverage are also confirmed by all components of debt. These results are in line with those of Jensen and Meckling (1976) and Myers (1977) whose tradeoff theory suggests that firms with greater fixed assets can use those assets as collateral and, therefore, issue more debt. Shah and Hijazi (2004) generate the same results. The firm size and leverage relationship is in line with the bankruptcy cost theory on leverage, i.e., that the fixed direct costs of bankruptcy constitute a smaller portion of the firm's total value and, thus, larger firms are willing to take on more debt because of the smaller chances of their going bankrupt. These results do not, however, confirm Rajan and Zingales's (1995) argument concerning less asymmetric information about large firms, suggesting that new equity issue will not be underpriced and that large firms will, therefore, issue more equity.

4.3. Results of Dynamic Panel Models

In the second stage, we estimate a series of dynamic panel models for all four categories of leverage to examine the inertia effect on firms' debt choices (Table 3). Firms that previously relied more heavily on debt are thought to follow the same trend, and the lagged leverage term is added to the set of explanatory variables. The Hausman specification test confirms that the fixed effects model fits the data well in the case of all four models.

Table 3: Determinants of capital structure components (dynamic panel model)

	Nonequity liabilities-to-total assets	**Debt-to-total assets**	**Debt-to-capital**	**Adjusted debt-to-adjusted capital**
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Leverage (–1)	0.75	0.61*	0.83*	0.94*
	(4.75)	(3.76)	(11.48)	(3.69)
Growth	–0.02	–0.01***	–0.08*	0.09
	(–1.21)	(–1.66)	(–3.08)	(0.16)
Size	0.11*	0.04*	0.05*	0.09*
	(6.26)	(3.63)	(2.13)	(2.71)
Profitability	–0.10*	–0.10**	–0.10*	–0.09*
	(–2.27)	(–1.88)	(–2.02)	(–2.56)
Tangibility	0.52*	0.24*	0.12*	0.25*
	(10.40)	(11.42)	(9.13)	(2.72)
C	–0.87*	–0.39*	–0.20	0.31
	(–12.27)	(–3.46)	(0.95)	(4.58)
Hausman	880.70	858.50	567.60	557.70
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)
R^2	0.67	0.68	0.85	0.34

Note: The covariance matrix is White heteroscedastic-adjusted; t-values are given in parentheses below coefficients. Asterisk(s) *, **, and *** indicate significance at 1, 5, and 10 percent, respectively.
Source: Authors' calculations.

Lagged leverage has a positive and statistically significant relationship with all categories of debt, confirming the presence of the inertia effect in firms' debt choices. The determinants follow the same pattern among all forms of debt as obtained from the ordinary panel analysis with fixed effects. Both firm size and tangibility have a positive relationship while profitability and growth opportunities have a negative relationship with the three components of debt; adjusted debt-to-adjusted capital shows no association between growth opportunities and leverage. These results show a clear distinction compared to long-term forms of debt and indicate that, for Pakistani firms, the determinants of the level of debt differ significantly depending on which element of debt is being examined.

4.4. Results of Panel Model Using Industrial Dummies

Since the Hausman specification test has confirmed the presence of fixed effects in cross-section units and no time-specific effects, we construct dummy variables to capture industry-specific effects for nine industries. These variables take a value of 1 for a particular industry and 0 otherwise. Of the nine industries, the tyres and wheels sector is used as a base category (D9). The remaining dummies are (i) D1 (oil and gas), (ii) D2 (chemicals and fertilizer), (iii) D3 (engineering), (iv) D4 (automobiles), (v) D5 (cement), (vi) D6 (paper and board), (vii) D7 (textiles), and (viii) D8 (refineries).

The results of this regression indicate that tangibility is positively and profitability negatively associated with leverage in all four forms, supporting the pecking order hypothesis. However, growth opportunities have a negative link with the first three components of debt and a positive relationship in the case of adjusted debt-to-adjusted capital. Size has a negative relationship with leverage when debt is defined as nonequity liabilities-to-total assets or debt-to-capital, and a positive relationship when it is defined as debt-to-total assets or adjusted debt-to-adjusted capital. The results of almost all the industrial dummies are significant, confirming the presence of individual effects in fixed form. These results indicate the robustness of the findings in that the traditional determinants play a role in debt decisions but are different among different components of debt.

Overall growth opportunities have a weak relationship with all components of capital structure except for the fourth component, i.e., adjusted debt-to-adjusted capital. The insignificant parameter on growth indicates that firms' growth opportunities have no impact on debt, which is contrary to expectations. Firm size has a positive and significant relationship with two components of capital structure, i.e., the long-term debt-to-total assets ratio and long-term debt-to-capital ratio; and a negative relationship with two other components, i.e., the nonequity liabilities-to-total assets ratio and adjusted debt-to-adjusted capital ratio. This result is consistent with the argument that larger firms have greater access to loans but, at the same time, require more financing for their operations.

Table 4: Determinants of capital structure components (model with industrial dummies)

Variable	Nonequity liabilities-to-total assets Model 1	Debt-to-total assets Model 2	Debt-to-capital Model 3	Adjusted debt-to-adjusted capital Model 4
Growth	–0.07*	–0.04*	–0.20	0.07
	(–11.52)	(–10.91)	(–9.74)	(3.66)
Size	–0.11*	0.04*	0.02*	0.22*
	(–4.61)	(8.60)	(–3.18)	(10.87)
Profitability	–0.16*	–0.15*	–0.29*	–0.30*
	(–13.10)	(–5.15)	(–3.48)	(–4.98)
Tangibility	0.36*	0.53*	0.44*	0.06*
	(16.89)	(31.61)	(8.70)	(2.24)
D1	0.04	0.17*	0.21*	–0.61
	(0.03)	(18.49)	(7.00)	(–6.35)
D2	–0.21*	0.05*	0.14*	–0.45*
	(–3.88)	(3.62)	(11.74)	(–3.85)
D3	–0.16*	0.01	–0.10*	–0.11
	(–13.10)	(0.72)	(–2.02)	(–0.85)
D4	–0.15*	0.02	0.38*	0.59*
	(–2.71)	(0.68)	(2.28)	(5.31)
D5	–0.27*	–0.04*	0.07*	–0.48*
	(–5.62)	(2.43)	(2.33)	(–4.01)
D6	0.41*	–0.01	0.07*	–0.41*
	(9.00)	(0.35)	(7.57)	(–3.72)
D7	–0.27*	0.06*	0.11*	–0.15
	(–7.10)	(2.34)	(14.21)	(–1.28)
D8	0.38*	0.01	0.14*	0.34*
	(7.40)	(0.55)	(7.21)	(–2.31)
C	–0.48	0.01	–0.10	–1.26*
	(–1.73)	(0.98)	(–0.67)	(–4.36)
R^2	0.62	0.64	0.30	0.34

Notes: The covariance matrix is White heteroscedastic-adjusted; t-values are given in parentheses below coefficients. Asterisk * indicates significance at 1 percent.
Industry dummies are introduced for nine sectors: D1 = oil and gas, D2 = chemicals and fertilizers, D3 = engineering, D4 = automobiles, D5 = cement, D6 = paper and board, D7 = textiles, D8 = refineries, and D9 = types and wheels. D9 is used as a reference category.
Source: Authors' calculations.

Table 4's results identify a negative relationship between profitability and all the components of capital structure. This implies that high-profit firms prefer internal to external sources to finance their operations. This result is consistent with the pecking order hypothesis, which states that firms will finance their operations in a specific order of preference, i.e., internal sources, followed by external sources of financing. Our results also reveal that tangibility has a strong positive relationship with all components of capital structure, indicating that firms with greater fixed assets will have more access to short- and long-term loans since they can use those assets as collateral against loans.

Our analysis of these components of debt underscores the importance of considering both long- and short-term debt and their determinants as separate categories. Therefore, an analysis of the determinants of debt based on total liabilities does not clarify the significant differences between long- and short-term debt, as documented by Van der Wijst and Thurik (1993), Chittenden, Hall, and Hutchinson (1996), and Barclay and Smith (1999). Our results reveal that the determinants of the level of debt issued by nonfinancial KSE-listed firms vary significantly depending on which component of leverage is being analyzed. We find that firm size is positively related to long-term debt rather than short-term debt forms. The fact that small firms are found to borrow in the short term rather than in the long term may indicate that they are supply-restricted since they do not have access to long-term borrowing.

The parameters on all the other most disaggregated debt elements are insignificant, and the relationship between the adjusted debt-to-adjusted capital ratio, trade credit and equivalents, and the market-to-book ratio is negative and significant. Therefore, firms with strong future growth opportunities will prefer to finance themselves using internal enterprise credit rather than through more formal means. This conforms to Barclay and Smith's (1999) observations, who suggest that, when looking for debt financing, firms with high levels of growth potential prefer short- to long-term debt, as well as debt with fewer restrictive agreements to allow them more financial flexibility. These results concerning the different categories of debt are consistent with the findings of Rajan and Zingales (1995) and Bevan and Danbolt (2000).

Adjusted debt-to-adjusted capital comprises mostly long-term debt components, whereas the nonequity liabilities-to-total assets measure includes elements of short-term liabilities, in particular trade credit, the major component of debt for the average KSE-listed nonfinancial firm. The decomposition results reveal that the positive relationship between the market-to-book ratio and the nonequity liabilities-to-total assets ratio is due to the short-term nature of this measure. This confirms the hypothesis that the significant differences between debt measures and their determinants imply that the expected theoretical relationships in corporate financing depend on which component of debt is under investigation. The results confirm the presence of the inertia effect in debt decisions. The significant industry dummies indicate that debt decisions depend on the sector being considered.

5. Conclusion

This study has analyzed capital structure in detail by carrying out panel data regressions for 77 nonfinancial firms for the period 2008–2010. We have examined four components of capital structure: the ratios of (i) nonequity liabilities to total assets, (ii) debt to total assets, (iii) debt to capital, and (iv) adjusted debt to adjusted capital. Growth opportunities have a weak relationship with two components of capital structure—the ratio of long-term debt to total assets and that of long-term debt to capital—while the ratio of nonequity liabilities to total assets has a positive relationship and that of adjusted debt to adjusted capital has a negative relationship with a firm's growth potential.

Firm size has a positive and significant relationship with the long-term debt-to-total assets ratio and long-term debt-to-capital ratio; and a negative relationship with the nonequity liabilities-to-total assets ratio and adjusted debt-to-adjusted capital ratio. This result can be justified with the argument that larger firms have greater access to loans but require more resources to finance their operations.

We have identified a negative relationship between profitability and all four components of capital structure, indicating that high-profit firms prefer to finance their operations through internal rather than external sources. This result is consistent with the pecking order theory, which postulates that firms arrange to finance their operations in a specific order of preference, i.e., initially through internal sources and then through external sources.

Reflecting Jensen and Meckling's (1976) and Myers' (1977) trade-off theory, our study reveals that tangibility has a strong positive relationship with all components of capital structure. This result shows that firms with greater fixed assets will have more access to short- and long-term loans because they can use these fixed assets as collateral. Our main findings suggest that an analysis of debt based solely on long-term debt does not provide a clear understanding of how firms make financial decisions; a complete picture of the determinants of capital structure requires a more rigorous analysis of all forms of corporate debt. Our results confirm the presence of the inertia effect and industry-specific effects, and are robust to alternative estimation techniques.

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Appendix

Table A1: Summary statistics

	Mean	Median	Stan. dev.	Skewness	Kurtosis
Leverage					
Lev_1	0.38	0.33	0.27	3.65	23.99
Lev_2	0.21	0.15	0.21	2.52	13.18
Lev_3	0.35	0.26	0.32	2.48	13.77
Lev_4	0.48	0.36	0.45	2.14	9.85
Explanatory variables					
Size	9.61	9.55	0.75	0.15	3.11
Growth	1.51	1.33	0.81	1.57	5.71
Profitability	0.18	0.13	0.22	1.86	8.50
Tangibility	0.47	0.46	0.29	1.11	5.74

Source: Authors' calculations.

Table A2: Correlations

	Lev_1	Lev_2	Lev_3	Lev_4	Size	Growth	Profit.	Tang.
Lev_1	1.000	-	-	-	-	-	-	-
Lev_2	0.539	1.000	-	-	-	-	-	-
Lev_3	0.325	0.556	1.000	-	-	-	-	-
Lev_4	0.275	0.314	0.419	1.000	-	-	-	-
Size	0.233	–0.117	0.026	0.205	1.000	-	-	-
Growth	–0.021	–0.152	–0.105	–0.053	0.103	1.000	-	-
Profit.	–0.262	–0.434	–0.288	–0.196	0.296	0.546	1.000	-
Tang.	0.129	0.619	0.542	0.073	–0.161	–0.030	–0.175	1.000

Source: Authors' calculations.

Table A3: Coefficients of covariance

	Lev_1	Lev_2	Lev_3	Lev_4	Size	Growth	Profit.	Tang.
Lev_1	0.076	0.044	0.031	0.029	0.069	–0.011	–0.011	0.039
Lev_2	0.044	0.044	0.040	0.003	0.004	–0.028	–0.013	0.044
Lev_3	0.031	0.040	0.104	0.021	–0.019	–0.038	–0.020	0.040
Lev_4	0.029	0.003	0.021	0.204	0.095	0.014	–0.014	–0.014
Size	0.069	0.004	–0.019	0.095	0.568	0.063	0.019	–0.035
Growth	–0.011	–0.028	–0.038	0.014	0.063	0.661	0.058	–0.019
Profit.	–0.011	–0.013	–0.020	–0.014	0.019	0.058	0.050	–0.011
Tang.	0.039	0.044	0.040	–0.014	–0.035	–0.019	–0.011	0.083

Source: Authors' calculations.

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The Consequences of Easy Credit Policy, High Gearing, and Firms' Profitability in Pakistan's Textile Sector: A Panel Data Analysis

Ijaz Hussain*

Abstract

This study uses panel data on 75 textile firms for the period 2000–09 to examine the consequences of an easy credit policy followed by high gearing, increased financing costs, and other determinants of corporate profitability. Five out of nine explanatory variables—including gearing, financing costs, inflation, tax provisions, and the industry's capacity utilization ratio—have a negative impact, while the remaining four variables—working capital management, asset turnover, exports, competitiveness, and devaluation—have a positive impact on firms' profitability.

Keywords: Easy credit, energy crisis, corporate profitability, textile sector, panel data, Pakistan.

JEL Classification: L78, L69, F14.

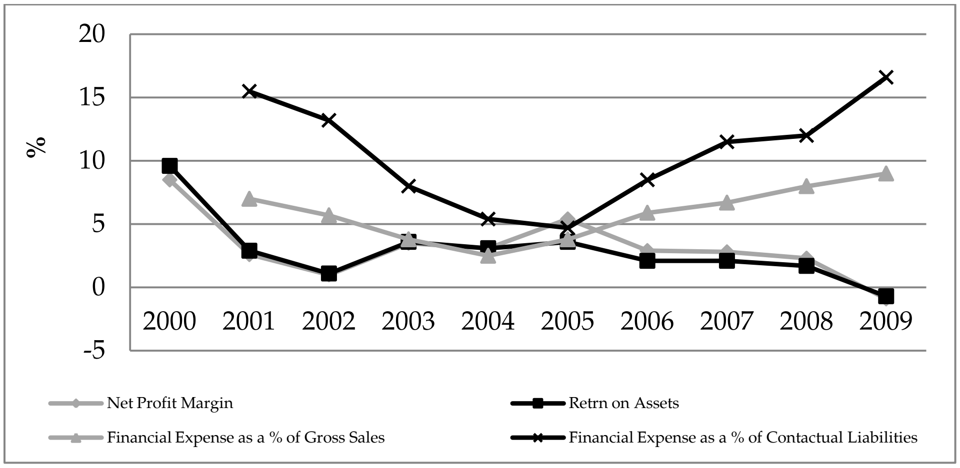
1. Introduction

Both the nonfinancial corporate sector (private and public enterprises) and financial sector play a critical role in a country's economic growth, because they produce goods and services for local as well as foreign markets, create job opportunities, contribute to government tax revenues to finance public expenditure on economic and social infrastructure, and sometimes also to foreign exchange reserves, thus playing an important part in the forward and backward linkages of the value chain.

Figure 1 shows that the profitability of Pakistan's textile sector has varied substantially across firms and over time, declining from almost 10 percent in 2000 to near 0 percent in 2009. This study examines the factors responsible for the variability of firms' profitability in the country's textile sector during this period.

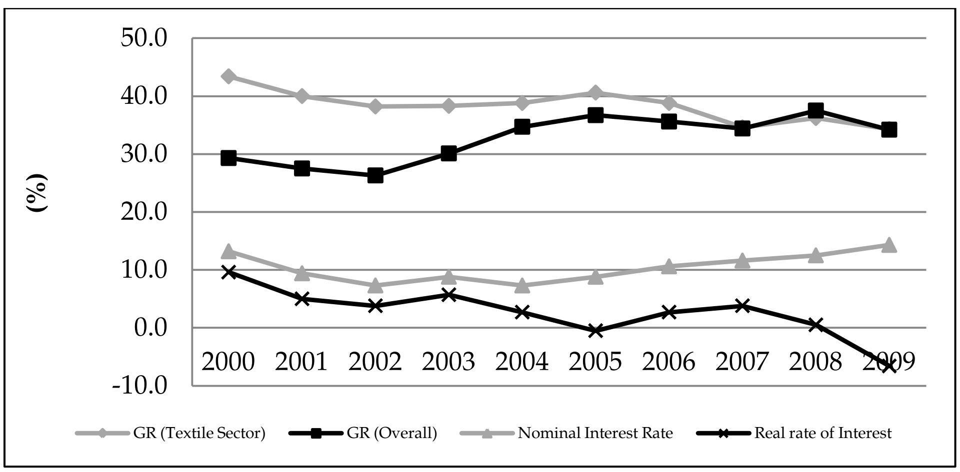
* Assistant Professor, School of Social Sciences, Beaconhouse National University (BNU), Lahore, Pakistan.

Figure 1: Profitability vs. financing costs in Pakistan's textile sector



As Figure 2 shows, the sector's gearing ratio peaked in 2005 due to the negative real interest rate followed by an explosion in its financing costs, which, along with the removal of the textile quota and acute energy crisis, later hampered the sector's profitability and ability to repay its debt and financing costs.

Figure 2: Interest rates and corporate gearing ratio



Source: State Bank of Pakistan (2010a, 2010b).

The State Bank of Pakistan (2010, December) reports loans of PKR 705.2 billion to the textile sector by the end of 2009, of which nonperforming loans accounted for PKR 171.5 billion, which constituted 31.3 percent of all total nonperforming loans. The gravity of the situation is evident from the fact that there were 189 textile firms in existence in 2004, which number fell to 164 in 2010 with the closure of 25 companies. This makes it important to understand the consequences of an easy credit policy followed by high gearing, increased financing costs, and other determinants of corporate profitability for textile firms in Pakistan.

The paper is organized as follows: Section 2 provides a review of the literature. Section 3 describes the data sources used, variables, and methodology. Section 4 presents our findings, and Section 5 puts forward a conclusion and policy recommendations.

2. A Review of the Literature

The empirical research on the determinants of corporate profitability can be classified into two categories: (i) structure-conduct performance models, and (ii) firm effect models (Mauri & Michaels, 1998; Schmalensee, 1989; Stierwald, 2010). The first explain profitability based on industry effects (concentration) while the second explain profitability based on variations in firms' characteristics (Stierwald, 2010). As noted by Bain (1951), a high industry concentration allows firms to exercise higher monopoly power in the market and makes collusion possible between firms, and thus gives them an opportunity to earn more profits. Barriers to entry of new firms allow existing firms to earn higher profits (Bain, 1956).

Lambson (1991), Jovanovic (1982), and Bartelsman and Doms (2000) highlight the persistent variation in firms' productivity. Demsetz (1973) points out that there is substantial variation in firms' characteristics, and that firms with higher productivity or efficiency earn higher profits. Ammar, Hanna, Nordheim, and Russell (2003) note that small, medium, and large firms differ significantly from one other in terms of their profit rate—profitability drops as firms grow beyond USD 50 million in sales.

Treacy (1980) identifies a strong negative correlation between firm size and the variance in returns on equity, and a moderate correlation between firm size and average returns on equity. As noted by Whittington (1980), the positive relationship between size and profitability is interesting because the larger firm size contributes to the high degree of concentration and monopoly power, and also to efficient cost structure due to scale economies.

Using a nonparametric approach, Grazzi (2009) proves that exporting activity is not systematically associated with firms' higher profitability. Based on the pecking order theory and using six years' data on textile firms in Pakistan, Amjed (2007) confirms the negative relationship between long-term debt and profitability, and the positive relationship between short-term debt and profitability. Ali (2011) analyze the association between working capital management and profitability in Pakistan's textile sector. He finds that average days in inventory, average days receivable, and average days payable have a significant economic impact upon return on assets.

Chhapra and Naqvi (2010) show that there is a strong positive and significant relationship between working capital management and firm profitability in Pakistan's textile sector. They also establish a significant relationship between the cost of production, size (capital), and profitability. Their results, however, indicate a significant negative relationship between a firm's debt and its profitability. Finally, Raza, Farooq, and Khan (forthcoming) provide evidence of a significant relationship between firm effects, industry effects, and market share and two measures of profitability, i.e., returns on equity and returns on assets.

3. Dataset, Variables, and Methodology

3.1. Data Sample

We use secondary data from the State Bank of Pakistan's (n.d.) *Balance Sheet Analysis of Joint Stock Companies Listed on the Karachi Stock Exchange* for the period 2000–09. The study's sample covers 75 firms of the textile industry (of a total of 164) with a complete and consistent 10-year data series. We exclude any firms that have an incomplete and/or inconsistent data series, or those that have negative equity.

3.2. Dependent and Explanatory Variables

The dependent variable is profitability, which is measured by the firm's return on assets (ROA).

The explanatory variables are as follows.

1. The financial gearing ratio (GR) equals long-term liabilities divided by total assets. This variable captures the impact of high gearing on profitability, followed by easy credit policy in the form of very low or negative interest rates.
2. Financing costs are represented by FCGS, and measured as a percentage of gross sales. This variable captures the impact of easy credit policy in the form of increased financing costs as an aspect of high gearing.

3. Efficiency is represented by asset turnover (ATO), which equals gross sales divided by the book value of total assets. This variable captures the impact of the extent of effective utilization of the firm's assets.
4. Size is represented by relative market share (RMS), and equals the firm's gross sales divided by the textile sector's gross sales. This captures the impact of an efficient cost structure due to economies of scale.
5. The capacity utilization ratio (CUR) is measured as actual operating spindles and looms divided by installed capacity, i.e., the impact of the industry's output supply on profitability.
6. Exports are represented by X, and are measured as sales to foreign countries. This variable captures the composite impact of changes in foreign demand on account of an increase in the international price of cotton, global financial crises, and removal of US quotas.
7. Competitiveness and devaluation are measured by the real effective exchange rate (REER), which captures their impact on the firm's profitability.
8. INF represents the rate of inflation.
9. TP represents tax provision in the firm's income statement.

Table 1 provides summary statistics for each of the variables described above.

Table 1: Summary statistics

Variable	Mean	Median	Maximum	Minimum	Standard Deviation	Observations
ROA	3.18	2.30	77.60	–187.70	11.82	750
GR	32.62	31.70	122.80	0.00	21.41	750
FCGS	5.54	4.70	250.00	0.00	10.16	750
ATO	107.44	99.35	438.90	0.90	53.24	750
RMS	1.39	0.76	14.75	0.00	1.71	750
CUR	65.20	65.75	69.50	60.50	2.81	750
X	1,023.82	317.75	1,8713.90	0.00	1,902.07	750
REER	100.06	99.20	106.60	97.10	2.86	750
INF	7.70	6.20	20.80	3.10	5.19	750
TP	42.59	9.20	1,3287.60	–8.80	493.56	750
CR	106.18	94.05	870.50	7.80	80.62	750

Source: Author's calculations.

Table 2 indicates correlation coefficients for each, which rule out multicollinearity between the variables.

Table 2: Correlation coefficients

	ROA	GR	FCGS	X	REER	INF	CUR	ATO	RMS	CR	TP
ROA	1.000	-0.137	-0.243	0.045	0.206	-0.232	-0.238	0.288	0.037	0.079	-0.060
GR	-0.137	1.000	0.031	0.050	-0.031	0.100	0.096	-0.139	-0.066	-0.261	0.017
FCGS	-0.243	0.031	1.000	0.052	-0.152	0.131	0.089	-0.213	-0.034	-0.040	0.150
ATO	0.288	-0.139	-0.213	-0.125	0.027	-0.210	-0.279	1.000	0.033	-0.083	-0.051
RMS	0.037	-0.066	-0.034	-0.013	0.089	-0.034	-0.026	0.033	1.000	0.165	0.017
CUR	-0.238	0.096	0.089	0.146	-0.212	0.460	1.000	-0.279	-0.026	-0.028	0.012
X	0.045	0.050	0.052	1.000	-0.138	0.151	0.146	-0.125	-0.013	0.133	0.027
REER	0.206	-0.031	-0.152	-0.138	1.000	-0.233	-0.212	0.027	0.089	0.011	-0.040
INF	-0.232	0.100	0.131	0.151	-0.233	1.000	0.460	-0.210	-0.034	-0.045	0.024
TP	-0.060	0.017	0.150	0.027	-0.040	0.024	0.012	-0.051	0.017	0.041	1.000
CR	0.079	-0.261	-0.040	0.133	0.011	-0.045	-0.028	-0.083	0.165	1.000	0.041

Source: Author's calculations.

3.3. Research Methodology

Using panel data we consider the following simple regression model:

$$ROA_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 W_i + \beta_3 Z_t + u_{it} + z_t \quad (1)$$

ROA denotes profitability, *i* specifies the cross-section dimension (firms), and *t* the time dimension of the dataset. β_0, β_1, β_2, and β_3 are unknown constants; X_{it} represents a set of firm-specific explanatory variables that vary across firms as well as over time; W_i represents a set of variables that vary across firms; Z_t is a set of macroeconomic or institutional explanatory variables that vary over time only; and u_{it} and z_t are both error terms.

Depending on the structure of the error term and the nature of its correlation with the explanatory variables, there are several ways of estimating our profitability model. Using ordinary least squares is appropriate if no unobservable firm- and time-specific factors exist, but both may exist in practice. A random effects model is appropriate when unobservable effects are included in the error term and the variance-covariance matrix of nonspherical errors is transformed to produce consistent estimates of the standard errors. The random effects estimator, however, becomes inconsistent when the unobservable effects included in the error term are correlated with some or all of the regressors. Though relatively inefficient, an alternative is the fixed effects model, which provides consistent estimates regardless of the aforementioned correlation.

Setting $\beta_0 + \beta_2 W_i = \alpha_i$ in equation (1).

We can rewrite the equation as

$$ROA_{it} = \beta_1 X_{it} + Z_t + \alpha_i + u_{it} + z_t \quad (2)$$

In this fixed effects the slope coefficient β_1 is the same for all firms; the intercept term α_i varies across firms but is constant over time.

4. Findings

We test for evidence of cross-section and period effects, and then determine whether they are correlated with the regressors. Our tests show that there is strong evidence of period and cross-section random and fixed effects. The fixed effects specification used includes variables that vary across firms and over time, and cross-section and period dummy variables. Testing the joint significance of the cross-section and period dummy variables reveals that both cross-section and period fixed effects are significant at 1 percent (Table 3).

Table 3: Redundant fixed effects tests: Cross-section and period fixed effects

Effects test	Statistic	d.f.	Probability
Cross-section F	1.906715	–74,659	0.0000
Cross-section Chi-squared	145.507	74	0.0000
Period F	8.357657	–9,659	0.0000
Period Chi-squared	81.06278	9	0.0000
Cross-section/period F	2.739911	–83,659	0.0000
Cross-section/period Chi-squared	222.3442	83	0.0000

Source: Author's calculations.

We also estimate a random effects model, to which we apply the Hausman (1978) test, the results of which lead us to reject endogeneity in the model. The variance between the coefficients of the random and fixed effects models is nonzero, which restricts us to relying on the fixed effects model alone. Table 4 presents the results of the cross-section fixed effects model.

Table 4: Regression Results

Dependent variable		ROA		
Sample period		2000–09		
Cross-sections included		75		
Variable	**Coefficient**	**Standard Error***	**t-Statistic**	**Probability**
C	–25.2423	5.9503	–4.2422	0.0000
GR	–0.0684	0.0110	–6.2275	0.0000
FCGS	–0.1882	0.0835	–2.2539	0.0245
X	0.0004	0.0001	3.5691	0.0004
REER	0.4518	0.0550	8.2150	0.0000
INF	–0.1888	0.0378	–4.9999	0.0000
CUR	–0.2862	0.0526	–5.4374	0.0000
ATO	0.0414	0.0054	7.7216	0.0000
RMS	0.4790	0.1614	2.9681	0.0031
CR	0.0100	0.0058	1.7107	0.0876
TP	–0.0001	0.0002	–0.6318	0.5277
Weighted Statistics				
R-squared	0.646237	Mean dependent variable	7.227636	
Adjusted R-squared	0.601551	SD dependent variable	15.77015	
SE of regression	9.785042	Sum squared residuals	63,671.79	
F-statistic	14.46175	Durbin-Watson statistic	1.579726	
Prob. (F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.317915	Mean dependent variable	3.184000	
Sum squared residuals	71,364.79	Durbin-Watson statistic	2.096149	

*White diagonal standard errors.
Source: Author's calculations.

It is worth noting that high gearing has a negative effect on firm profitability, which confirms the hypothesis that high gearing was followed by higher financing costs on one hand and ineffective utilization of assets during the acute energy crisis period on the other—that is, higher financing costs accompanied by ineffective utilization of assets, financed by long-term borrowing on account of extremely low or negative real interest rates during the first half of the 2000s. The negative sign of the gearing coefficients is also consistent with the findings of Chhapra and Naqvi (2010). The negative sign of the financing costs variable further supports the negative and significant impact of high gearing.

The study's regression results show that, despite the global financial crisis, devaluation and the increase in international cotton prices have led to an improvement in the profitability of exporting firms.[1] The positive sign of competitiveness and devaluation variable (REER) also supports the positive sign of the exports variable (X).

The negative impact of inflation is worth noting because a higher rate of inflation in Pakistan may cause foreign importers to switch to other countries, reducing demand and, therefore, firms' operations to below capacity, in turn causing the latter's profitability to decline. The negative sign of the industry's CUR variable reveals that a higher CUR increases the market supply of textile output, leading to a decline in the price of textile products and, hence, in profitability.

Efficient firms, or firms with a higher ATO (those that make relatively more effective use of their assets) have a higher profitability rate. The positive relationship between size and profitability is interesting because larger firm size contributes to a more efficient cost structure due to the presence of economies of scale (see Whittington, 1980). The positive sign of the size variable contradicts the findings of Treacy (1980) and Ammar et al. (2003). The positive sign of the current ratio indicates that firms with better working capital management are more profitable. Tax provisions, however, have a negative but insignificant impact on firms' profitability.

Those firms that opted for higher gearing in 2005 due to the extremely low nominal interest rate and negative real interest rate prevailing at the time have recently begun to face the consequences of high gearing. The subsequent energy crisis in the country has significantly impacted firms' operations and, as a consequence, those with squeezed sales and higher financing costs on account of the higher interest-bearing debt are now subject to lower profitability or losses. This, in turn, has contributed to nonperforming loans, which could prove a challenge for the financial sector.

5. Conclusion and Policy Implications

This paper has examined the impact of an easy credit policy followed by high gearing, increased financing costs, and other determinants of the corporate profitability of textile firms in Pakistan. Of nine explanatory variables, including gearing, financing costs, inflation, tax

[1] This is, however, not consistent with Grazzi's (2009) results.

provisions, and the industry’s capacity utilization ratio, five have a negative impact on firm profitability, while four variables, including working capital management, asset turnover, exports, and competitiveness and devaluation, have a positive impact.

These results have serious implications for corporate managers and policymakers. They highlight that the consequences of a liberal credit policy must be considered in terms of corporate profitability and that corporate managers should be cautioned to refrain from opting for high financial leverage, instead keeping in mind likely long-term changes in economic conditions and the external environment. Managers can improve corporate profitability by better managing their working capital, improving asset turnover, benefitting from economies of scale by adjusting size in the long run, and enhancing export capacity especially during a devaluation of the local currency. Managers should also attempt to improve the quality of their products so that they are more competitive in international markets, which in turn will increase firms’ exports and profitability.

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Human Capital Convergence: Evidence from the Punjab

Uzma Afzal[*]

Abstract

While the literature on economic growth provides mixed evidence on convergence across different countries and regions, a large number of studies point toward the widening income gap between rich and poor. In the development literature, a broader range of national welfare indicators beyond income per capita—health and education in particular—are considered important instruments for measuring progress in human development. This article examines education and other selective welfare indicators to determine if there has been unconditional and conditional convergence across the districts of Pakistani Punjab over the period 1961–2008. The study can be considered part of the growing literature that looks at growth theory in developing countries in the context of human capital. Thus far, few studies have examined human capital in the context of convergence, and Pakistan has not been studied in any depth up to now. The results of our empirical analysis show that over the last five decades, both unconditional and conditional convergence has taken place in literacy rates across Punjab, and that this has been accompanied by increased gender parity in educational enrolment levels and improved housing conditions.

Keywords: Human capital, unconditional convergence, conditional convergence, Pakistan.

JEL Classification: I31, R10.

1. Introduction

The variations in countries'/regions' economic performance has fueled the debate on convergence in their growth rates to determine if initially disparate countries/regions are converging to common steady-state levels. The literature on economic growth provides mixed evidence on this, and many studies point toward the widening income gap between rich and poor. In the development literature, a broader range of national welfare indicators beyond income per capita—health and education in particular—are considered key instruments for measuring progress in

[*] Senior Research and Teaching Fellow, Centre for Research in Economics and Business (CREB), Lahore School of Economics, Pakistan.

human capital development. With the rising divergence of income levels across the world, it is pertinent to ask whether such divergence is also occurring in the different aspects of human development.

This study examines three human development indicators—housing, education, and health—to determine if there has been convergence across the districts comprising Pakistani Punjab over the period 1961–2008. It also focuses on convergence in education outcomes across gender to determine if the gaps between male and female enrolment levels have changed over the last six decades. The study is effectively part of the growing agenda to investigate concepts of growth theory in developing countries in the context of human capital. Given that income per capita alone is not sufficient to determine people's welfare status, by looking at convergence in social welfare indicators we attempt to study development in a new light. Few studies have examined human capital in the context of convergence and Pakistan has not been studied in depth in any such work; this study is, therefore, among the first to do so.

There is growing concern that regional inequality in Pakistan has worsened over the past few decades (Abbas & Foreman-Peck, 2008; Khan, 2001). Inequitable growth has also been a cause of concern for other developing countries such as China and India. As Pakistan's largest and most diverse province, Punjab has been criticized for holding the majority of the country's wealth compared to other provinces and, within Punjab, the unbalanced division of resources has fueled the call for Punjab to be divided into new, smaller provinces.

A number of studies on Pakistan find that the intensity of poverty increases as one moves toward the southern and western regions. Literacy rates and enrolment levels, along with access to basic public goods such as electricity, gas, and sanitation, are far lower in the southern and western districts than elsewhere (Cheema, Khalid, & Patnam, 2008; Khan, 2009). Afzal (2010) shows that patterns of human welfare across Punjab have persisted over the last five decades, and concludes that less developed districts have been unable to break out of their lagging status. Whether these gaps among Punjab's districts have increased or decreased, however, remains unexplored.

The article is organized as follows: Section 2 provides an overview of the literature on growth and human capital convergence. Section 3 puts forward a theoretical understanding of the concept and types of convergence. Section 4 describes the data used and presents the study's results for convergence in Punjab. Section 5 provides a brief conclusion drawing on the estimates presented in Section 4.

2. A Brief Review of the Literature

The growth literature comprises numerous cross-country studies and, more recently, intra-country studies that explore initially disparate regions that converge to common steady-state paths (see Barro, 1991; Barro & Sala-i-Martin, 1991; Baumol, 1986; Button & Pentecost, 1995; De Long, 1988; Jian, Sachs, & Warner, 1996; Jones, 1997; Maasoumi & Wang, 2008; Mankiw, Romer, & Weil, 1992; Pritchett, 1997; Sachs, Bajpai, & Ramiah, 2002; Trivedi, 2002). The pioneering work of Barro and Sala-i-Martin (1991) finds evidence of convergence across countries and, in the same notion Mankiw et al. (1992) observe convergence across countries by introducing other qualitative variables into their model.

The more recent literature portrays a different picture—that of rising growth rates accompanied by greater divergence across the world. According to Maddison (2001), in 1000 AD, Africa and western Europe had the same GDP per capita but, by 1998, the latter had become 13 times richer. Although developing countries such as China and India are rapidly closing in on the income gaps that separate them from the developed world, regional disparities have begun to emerge within the former.

The notion of wealth as the only indicator of welfare was contested centuries ago, and is still a matter of debate in some spheres. Over the years, development economists have kept pace with growth economists and produced studies exploring the importance of education and health in economic development. For most development economists, the quality of life is better determined by human and social capital rather than by simple measures such as per capita income/GDP. Kenny (2005) argues that income is considered important mainly because it is assumed to reflect the quality of life.

So, if incomes are diverging, then perhaps people's quality of life across different countries is also diverging. In studying this income–quality-of-life relationship, a number of economists have found that conventional wisdom does not hold true. Some studies have shown that income can account for a very small percentage of increase in people's social wellbeing (see Easterly, 1999; Preston, 1975). Easterly (1999) finds that most quality-of-life variables are not correlated with a country's growth rate and that its welfare indicators may actually have been improving over the past few decades.

According to Kenny (2005), most analyses on the issue of relative growth in quality-of-life variables find evidence of convergence. Numerous studies also confirm the significance of education and health in the development process. In a cross-country study, de Babini (1991) examines the enrolment level, participation of women in education, and certain school indicators for the period 1960–1983. By looking at the coefficient of variation (CV) in a sample of over 100 countries, she finds convergence across all levels of education.

Ingram (1992) looks at a large sample of developed and developing countries and finds that the gaps in per capita GDP have increased among low-, middle-, and high-income countries. The author finds evidence of strong convergence across the sample for most social indicators in the analysis—life expectancy, caloric intake, primary enrolment ratio, and urbanization. Using data from 84 countries for 1970–1990, Sab and Smith (2002) ask whether health and education levels are converging across countries. They conclude that investments in education and health are closely linked, and that there is unconditional convergence for life expectancy, infant survival, and average levels of schooling in the adult population.

3. Two Concepts of Convergence

Drawing on the vast and burgeoning literature on growth, there are two main concepts of convergence: β-convergence and σ-convergence (Barro & Sala-i-Martin, 1995). The first applies if a poor country tends to grow faster than a rich country such that it catches up with the latter in terms of per capita income. Simply put, β-convergence assumes that initially poor countries tend to grow faster than rich ones. The key assumption generating from the neoclassical model is that of diminishing returns to reproducible capital, thus economies with lower stocks of physical capital will enjoy higher marginal rates of return on capital (Trivedi, 2002).

β-convergence has two forms: (i) conditional, and (ii) unconditional/absolute. Conditional convergence suggests that convergence depends on an economy's structural characteristics—those factors causing changes in its steady state—and that these structural differences mean that different countries will have different steady states relative to their per capita incomes (Lall & Yilmaz, 2000). Introducing additional structural variables into the basic growth regression can be used to test this.

A stronger kind of convergence takes place unconditionally or absolutely when initially poorer states grow faster, albeit under different initial conditions. With reference to the Solow model, if we assume that all regions in the long run have no tendency to show differences in the rates of investment, capital depreciation, population growth, and human capital formulation, etc., then such a model will result in unconditional convergence to a common value of per capita income (Trivedi, 2002). The assumptions behind unconditional convergence, however, might better fit regional datasets where different regions within a country are more similar than different countries with respect to technology and preferences (Barro & Sala-i-Martin, 1995).

The concept of σ-convergence concerns cross-sectional dispersion, and occurs if the dispersion of a particular indicator across a region declines over time (Barro & Sala-i-Martin, 1995). It can be measured by looking at the size of the standard deviation (SD) of the selected variable: A fall in the SD will imply convergence across the region over time. The CV is the ratio of the SD to the mean, and measures convergence relative to the mean; it is useful where variables are expected to trend upward across the world over time (Kenny, 2005). Barro and Sala-i-Martin (1995) argue that β-convergence (where poor countries tend to grow faster than rich ones) leads to σ-convergence, but that this process can be offset by new disturbances that tend to increase dispersion.

We will study human capital convergence, following the methodology of Trivedi (2002) and Sab and Smith (2001), who essentially adapt the basic framework laid down by Mankiw et al. (1992). The methodology is better explained by taking the example of an indicator that is included among the variables being analyzed in this article. Let us say that we are testing for convergence in literacy rates across the districts of Punjab:

$$\ln(lit_{i,t}) - \ln(lit_{i,t-\tau}) = \gamma \ln(lit_{i,t-\tau}) + \sum_{j=1}^{k} \pi^{j} x_{it-\tau}^{j} + \mu_i + \varepsilon_{it} \qquad (1)$$

lit_{it} is the literacy rate of district i at time t, x_{it} is the set of conditioning variables that captures the differences in steady states, μ_i is the country-specific fixed effect, ε_{it} is the error term that varies across regions and time periods and has a mean equal to 0, and γ is the convergence effect.

The difference in logs for literacy levels, which is the growth rate of literacy in the selected period, depends on the initial level of literacy and other complementary policies or endowments that may affect the growth of literacy rates. To test for absolute convergence, we do not control for steady-state determinants, and only the initial literacy levels appear on the right-hand-side. To control for heteroscedasticity of unknown form, we use robust standard errors alongside ordinary least squares estimates.

4. Testing for Human Capital Convergence

4.1. Data and Descriptive Statistics

This study draws on data from three sources: (i) the district census reports for 1961, 1981, and 1998 (Government of Pakistan, n.d.); (ii) the Punjab Development Statistics (Government of the Punjab, 1981, 2000); and (iii) the Multiple Indicator Cluster Survey (MICS) for 2007/08 (Government of the Punjab, 2008). The district census reports are among the earliest reports available at the district level; since the 1998 census was the last national census conducted, data for Punjab for 2008 is obtained from the MICS for 2007/08. The MICS is a cross-sectional micro-level dataset consisting of 91,075 households and 592,843 listed members.

Type of shelter and living conditions determine people's social and economic wellbeing. To gauge this, we include average household size, the number of rooms per housing unit, percentage of houses with brick (*pakka*) walls, and percentage of houses with reinforced (*pakka*) roofs.[1]

Next, we consider several education indicators: Male and female literacy rates (for persons aged 10 or above); gross enrolment rate (the number of students enrolled at a given level, regardless of their age, and expressed as a percentage of the corresponding eligible age group population for each level of education;[2] and enrolment rates at the primary, secondary, and tertiary level for both genders.

Due to the unavailability of output variables for health at the district level, we include variables that help determine the accessibility of health services: Hospitals per 10,000 population, and the number of patients treated as a percentage of the total population. Information on patients treated and the number of total hospitals and dispensaries in each district for 1981 and 1998 has been taken from the Punjab Development Statistics (see Government of the Punjab, 1981, 2000).

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[1] *Pakka* walls are constructed of brick or stone, and are cement-bonded. *Pakka* roofs are made of reinforced concrete and cement (RCC), reinforced brick and cement (RBC), or girder/beam and baked bricks.

[2] The age bracket for each level of education is: primary (5–9 years), secondary (10–14 years), and tertiary (15–24 years).

4.2. Estimating σ-Convergence

Table 1 presents descriptive statistics for the 1961–2008 data being used, including the mean, SD, and CV for the variables explained above. The changes in mean simply show whether there has been an overall change in the prevalence level of each of the variables; means testing—conducting a t-test on the values for two different years—allows us to determine if two means are statistically different from one other.

The SD, also known as σ-convergence, is the preferred measure of convergence if the absolute differences in a variable are considered the most important. The CV measures convergence relative to the mean and is more pertinent when absolute increases in the mean level are expected (Kenny, 2005). If all countries undergo similar absolute increases in an indicator, this would leave the SD unchanged, but it would overlook the decline in percentage differences across countries. The CV is unit-less, and therefore the choice of unit of measurement does not affect its size (Kenny, 2005). For this study, since the social indicators are expected to follow an upward trend during the selected period, the CV is considered a better instrument for measuring convergence.

In terms of housing indicators, the mean household size has increased from about five persons per household to seven. This reflects the dramatic increase in population in Punjab, even though the SD and CV both reflect divergence across the districts. If we examine these results and the data, the divergence implies that household size in the districts has increased but at different rates, i.e., in some districts, household size has increased much faster than in others.

Table 1: Descriptive statistics

Indicator	Mean [a]		SD [b]		CV [c]	
	1961	2008	1961	2008	1961	2008
Average household size	5.40*	6.50*	0.24	0.34	4.4	5.3
Rooms per housing unit	1.80*	2.08*	0.34*	0.13*	19.5	6.1
Households with *pakka* walls (%)	21.40*	73.20*	14.00	19.10	65.6	26.1
Households with *pakka* roofs (%)	7.50*	82.50*	4.14*	13.60*	55.9	16.5
Literacy rate (male)	20.00*	68.60*	7.40	10.40	37.1	15.1
Literacy rate (female)	5.57*	47.40*	3.40*	13.60*	60.7	28.8
Primary enrolment rate (male)	35.70*	103.30*	11.8	12.80	33.0	12.4
Primary enrolment rate (female)	17.40*	95.30*	3.40*	19.80*	47.3	20.8
Secondary enrolment rate (male)	27.10*	49.50*	9.52	18.90	35.1	38.2
Secondary enrolment rate (female)	6.20*	66.80*	4.90*	16.10*	79.4	24.2
Tertiary enrolment rate (male)	0.71*	10.30*	0.50*	2.40*	69.9	23.6
Tertiary enrolment rate (female)	0.19*	10.33*	0.28*	3.86*	148.0	37.4
Patients treated	0.44*	0.0008*	0.07	0.05	27.2	25.1
Hospitals per 10,000 population	0.369*	0.0236*	0.12*	0.00002*	19.8	21.4

Notes: Asterisk * indicates significance at 1 percent.
[a] P-values are based on the t-test for the significance of two means, where the null hypothesis states that the value of the ratio of the 2008 to 1961 mean is unity (against a two-tailed alternative)
[b] P-values are based on the variance ratio test, where the null hypothesis states that the value of the ratio of the 2008 to 1961 standard deviation is unity (against a two-tailed alternative)
[c] The coefficient of variation (CV) is the ratio of the standard deviation (SD) to the mean.
Source: Author's calculations.

The average number of rooms in a household has also increased across Punjab and the CV would suggest that there has been convergence across the districts. The percentage of households with *pakka* walls and roofs has increased several-fold, reflecting improved living conditions across all the districts. Although the SD has increased for both these variables,[3] we are interested in the results for the CV, in which there is no clear decline for houses with *pakka* walls and roofs. This implies that the overall structure of housing across Punjab has improved and that people are gravitating away from mud structures and inadequate shelter.

Male and female literacy rates are fundamental measures of human capital development. Both have increased considerably in Punjab, which

[3] The disparity in the results for SD and CV is also common in other studies (see Sab & Smith, 2001).

could reflect the cumulative impact of the education policy in previous years. From Table 1, we can see that, with rising literacy levels, there is also convergence in literacy rates across districts. Enrolment rates at all levels of education have risen dramatically. Both male and female primary enrolment rates have increased in volume, while the gaps between districts have declined over the same period. The female secondary enrolment rate follows the same trend and shows rapid improvement and convergence across the districts. Male secondary enrolment levels, however, show an overall increase but greater divergence across districts. Tertiary enrolment levels are nominal at the start of 1961 but have increased several-fold by 2008. A 10-percent tertiary enrolment rate is not impressive by international standards, but there has been improvement over the last four decades. The CV for the tertiary enrolments rate has also declined.

The two health indicators in the table show a decline in the mean levels from 1961 to 2008. Since the population has increased considerably over the given period and both indicators are a ratio of the population, the declining mean levels are not surprising. It also reflects the fact that the increase in health facilities in Punjab has not kept pace with the rise in number of people. Convergence across districts becomes trivial, therefore, when the entire province needs massive investments in health facilities across the board.

4.3. Estimating β-Convergence: Absolute or Conditional?

We also check to see if the second kind of convergence—β-convergence—also exists across districts of Punjab. We have a range of instruments with which to measure education—our variable of interest—and will therefore use it to gauge human capital. Since there is insufficient information on outcome variables for health, they will be discussed briefly along with housing variables.

4.3.1. Absolute/Unconditional Convergence

To examine unconditional convergence in a regression framework, The estimated model takes the following form:

$$\ln Y_{i,\,1961\text{–}2008} = constant + \gamma\,(\ln Y)_{i,\,1961} + \varepsilon_i \qquad (2)$$

A negative and significant value for γ implies unconditional or absolute convergence to a common steady state. Simply, a region with an initially lower level in a variable will experience higher growth in that variable.

Table 2 reports our estimates, with the results for four different periods presented in each column. The independent variable for each regression takes the value that prevailed at the start of the period. So, in column 1, the independent variables take the values of the year 1961 and the dependent variable is the average growth in the variable over the period 1961–2008. A negative and statistically significant value for the coefficient γ implies absolute convergence to a common steady state (Trivedi, 2002). From the results we can see that all the housing variables have significant negative coefficients, implying that there has been absolute convergence across all districts over the 50-year period.

Our estimates for male and female literacy rates for the period 1961–2008 by decade produce very encouraging results. With every successive decade, the lagging districts appear to close the gap between the more literate districts. The gender parity index measures female enrolment rates as a ratio of male enrolment rates to determine the parity between the sexes across education levels. The results for the gender parity index show that, for all three levels of education in Punjab, there has been unconditional convergence for the majority of estimates.

Overall, for the period 1961–2008, our results appear to strongly point toward a converging Punjab where female enrolment levels are catching up with male enrolment levels. Some exceptions exist in estimates by decade where some results emerge as not being statistically significant. Male and female enrolment rates at all levels have negative coefficients, which implies that there has been unconditional convergence in Punjab across all levels of education.

Table 2: Unconditional convergence

Independent variable (Initial period)	Estimated coefficient			
	1961–2008	**1961–81**	**1981–98**	**1998–2008**
Average household size	–0.216***	-	-	-
	(–0.227)			
Rooms per housing unit	–0.752***	-	-	-
	(0.059)			
Households with *pakka* walls (%)	–0.629***	-	-	-
	(0.059)			
Households with *pakka* roofs (%)	–1.020***	-	-	-
	(0.079)			
Literacy rate (male)	–0.576***	–0.455**	–0.406***	–0.274***
	(0.041)	(0.215)	(–0.089)	(0.026)
Literacy rate (female)	–0.551***	–0.494*	–0.474***	–0.280***
	(–0.058)	(0.236)	(0.156)	(0.048)
Gender parity index (primary)	–0.728***	0.314	–0.742***	–2.416***
	(0.122)	(0.437)	(0.062)	(0.846)
Gender parity index (secondary)	–1.254***	–0.405***	–0.418	–1.308***
	(–0.095)	(0.137)	(0.259)	(0.129)
Gender parity index (tertiary)	–0.915***	–0.827***	–0.481***	–0.085
	(0.065)	(0.109)	(0.117)	(0.177)
Primary enrolment rate (male)	–0.699***	-	-	-
	(0.084)			
Primary enrolment rate (female)	–0.380***	-	-	-
	(0.084)			
Secondary enrolment rate (male)	0.049	-	-	-
	(0.092)			
Secondary enrolment rate (female)	–0.750***	-	-	-
	(0.078)			
Tertiary enrolment rate (male)	–0.840***	-	-	-
	(0.066)			
Tertiary enrolment rate (female)	–0.828***	-	-	-
	(0.040)			
Patients treated	–0.831***	-	-	-
	(0.244)			
Hospitals per 10,000 population	–0.377	-	-	-
	(0.097)			

Notes: All estimates have been calculated using the logarithm of the dependent and independent variables—the dependent variable is the log difference of the independent variable in the given period.
Standard errors are given in parentheses. Asterisks ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively. We control for heteroscedasticity by controlling for robust standard errors when calculating estimates.
Source: Author's calculations.

The only exception is the male secondary enrolment rate, the result of which is not statistically significant. The speed of convergence (λ) for the male literacy rate is 0.018, implying that it would take 38 years for this variable to move halfway to the steady state.[4] For females, the speed of convergence is 0.017, indicating that it would take about 41 years for the female literacy rate to move halfway toward its steady state. In terms of health indicators, the number of patients treated as a percentage of the total population converge unconditionally across Punjab, but the prevalence of hospitals per 10,000 people does not reflect any patterns of convergence since the coefficient is not significant.

4.3.2. Conditional Convergence

To measure conditional convergence in human capital across the districts of Punjab, we focus primarily on the outcome variables of education, i.e., literacy rates. As already stated in the previous sections, additional steady-state variables are introduced on the right-hand-side of Equation 2 to test for conditional convergence. The choice of these additional variables depends on economic theory, beliefs concerning the development process, the economic literature, and data availability (Sab & Smith, 2001; Trivedi, 2002). In order to calculate estimates, we include household-level indicators to control for the steady-state level of literacy rates. Since our aim is to look for forces of convergence in the data rather than to test for a particular model of convergence or for the impact of control variables, we continue to focus on the coefficient of the literacy rate's initial level in Punjab. Table 3 presents the results from the estimates.

The coefficient of the male literacy rate for 1961 is negative and statistically significant at 1 percent, strongly suggesting the presence of conditional convergence across all districts of Punjab. Similarly, the coefficient of the female literacy rate for 1961 is significant and negative, also suggesting conditional convergence. The values for λ are, in general, higher for conditional convergence results than those for unconditional convergence. Under conditional convergence, the male literacy rate moves halfway to the steady state in about 20 years, while the female literacy rate takes 26 years.

[4] The speed of convergence, λ, of a given variable is calculated by taking the negative of the natural log of 1 plus the coefficient of the lagged dependent variable divided by the period under observation. Thus, λ, = $-\ln(1 + b)/\tau$ where τ is the period under analysis. The half-life, t^*, is the solution to $e^{-\lambda t^*} = 0.5$. Taking logs of both sides, $t^* = -\ln(0.5)/\lambda$ (Sab & Smith, 2001).

Table 3: Conditional convergence

	Dependent variable: 1961–2008	
Independent variable	**Literacy rate (male)**	**Literacy rate (female)**
Literacy rate (male) 1961	–0.804***	-
	(0.078)	
Literacy rate (female) 1961	-	–0.709***
		(0.089)
Average household size	–0.451*	–0.034
	(0.248)	(0.552)
Rooms per housing unit	0.316**	0.459*
	(0.116)	(0.247)
Households with *pakka* walls (%)	0.043	0.080
	(0.039)	(0.098)
Households with *pakka* roofs (%)	0.020	–0.035
	(0.019)	(0.044)

***Notes**:* All estimates have calculated using the logarithm of the dependent and independent variables—the dependent variable is the log difference of the independent variable over the period 1961–2008.
Standard errors are given in parentheses. Asterisks ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively. We control for heteroscedasticity by controlling for robust standard errors when calculating estimates.
***Source**:* Author's calculations.

This section has examined the hypotheses of unconditional and conditional convergence, following the neoclassical growth models. Education is a fundamental measure of human capital and the empirical results suggest the presence of both unconditional and conditional convergence in education and, therefore, in human capital.

5. Conclusion

We have examined patterns of human capital convergence across Punjab for the period 1961–2008. Since there are no major studies on the subject for Pakistan, let alone Punjab, we have compared our results with findings on other countries and regions. Given that the results on income convergence across countries are controversial, studies examining quality-of-life variables show their convergence almost unambiguously. On implementing the two main measurement techniques of convergence—σ- and β-convergence—we have found that most of the instruments of human capital and welfare in our data converge over the period 1961–2008. The average household size across Punjab's districts increases during the study period, implying that the population burden on national resources also rises.

In testing for unconditional convergence, our results have shown convergence across household size, although the CV suggests otherwise; we cannot, therefore, conclusively suggest that this indicator shows signs of convergence. Moreover, housing conditions in Punjab have, overall, improved over time as concrete constructions are substituted for inadequate residential structures.

Gender parity across enrolment levels has increased, which means that more girls are now enrolled alongside boys. The primary enrolment rate for males, secondary enrolment rate for females, and tertiary enrolment rates for both genders have very high rates of convergence across districts. Since only one indicator—the number of patients treated as a percentage of the total population—of the two variables in our analysis shows signs of strong convergence, we cannot draw any significant conclusions concerning health.

The overall increase in literacy rates, gender parity, enrolment rates, and housing conditions are important achievements in themselves; that initially backward districts have caught up with more developed districts is an even more important achievement. This implies that the seemingly downtrodden districts of Punjab are not so disadvantaged when initial conditions are taken into context. It also implies that, with time, the gaps will continue to shrink should no major changes occur in the political economy.

That said, it should be pointed out that the average literacy and enrolment rates in Punjab and in Pakistan overall are not impressive in comparison with other developing countries with similar income levels. The positive trends and encouraging results brought out by this study do not allow for complacency, rather they advocate even greater effort on the government's part to invest in education and health. Greater provision of public health facilities and educational institutions is crucial to build on human capital development. Investment in these two sectors will consequently have positive spillovers on infant survival rates, spread of communicable diseases, and life expectancy.

Our findings also provide important insights into the growth process in Punjab. Keeping in mind the common perception that districts in Punjab have undergone both inequitable growth and division of national resources, the study's empirical results suggest that we can expect conditional income convergence eventually, given that human capital convergence is already underway in all other districts of the province.

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Does Access to Modern Marketing Channels Improve Dairy Enterprises' Efficiency? A Case Study of Punjab, Pakistan

Sana Sadaf[*] and Khalid Riaz[**]

Abstract

The main objective of this study is to investigate how access to modern marketing channels impacts the efficiency of dairy enterprises. Using data on dairy farms in central Punjab (Sargodha), we carry out a nonparametric data envelopment analysis to measure their technical and scale efficiencies. The results show that, for the sample dairy enterprises, the mean technical efficiency under variable returns to scale was 0.89 while scale efficiency was 0.94. The results of a follow-on regression analysis support the hypothesis that the access to modern marketing channels, where payment for fresh milk is based on measured milk quality (fat content), improved efficiency. We find that efficiency is positively affected by the size of dairy operations, and negatively by the size of operational land area. Moreover, dairy enterprises with smaller herds tend to operate at a suboptimal scale, possibly due to credit and/or land constraints.

Keywords: Dairy, marketing, Punjab, Pakistan.

JEL Classification: C14, M31.

1. Introduction

The agricultural sector plays a significant role in Pakistan's economic development; the sector contributed 21.9 percent to the country's gross domestic product (GDP) in 2007/08. Livestock is the single largest subsector within agriculture, accounting for roughly 52 percent of agricultural value-added (Government of Pakistan, 2008). In Pakistan, about 30–35 million people are engaged in livestock-related activities, and 30–40 percent of their income is generated from these activities (Riaz, 2008).

The dairy subsector is in the process of being commercialized, although the bulk of production still takes place at millions of

[*] Graduate Student of Economics, University of Sargodha, Pakistan.
[**] Professor, Department of Management Sciences, COMSATS Institute of Information Technology, Islamabad, Pakistan.

geographically dispersed farms. Milk supply chains involve various marketing intermediaries, ranging from milk collectors known locally as *dodhis*[1] who dominate traditional marketing channels, to large commercial dairy processing firms that procure milk through modern marketing channels, and sell packaged UHT-treated milk and other milk products produced in their own plants.

The milk marketing system in Pakistan is unregulated. There are significant differences in terms of adherence to food safety standards and milk quality (e.g., fat content) collection through traditional versus modern marketing channels. In the case of the former, unrefrigerated milk may sometimes be moved over considerably long distances and during hot weather. It is not packaged at any stage of the supply chain and is of highly variable quality.[2] Moreover, to prevent it from spoiling during transportation, traditional market intermediaries may add to it various chemicals or ice made from water which is unfit for human consumption.

On the other hand, the commercial dairy firms that operate in modern marketing channels have typically established cool chains with chillers located in their procurement areas. Moreover, the milk quality, including fat content, is tested at each stage during transportation to ensure adherence to food safety standards. The prices that farmers receive for fresh milk sold to commercial dairy firms are based on measured milk fat content.[3] However, not all commercial firms procure milk directly from the farmers. Firms with inadequate supply chain infrastructure have chillers in the area but not an elaborate network of village milk collection (VMC) centers. These firms allow traditional *dodhis* to collect milk from nearby villages and deliver it to their chillers.

From a food safety perspective, it is highly desirable that the bulk of Pakistani milk production moves through supply chains managed by modern marketing channels to ensure food safety and quality standards.

[1] Milk vendors who collect milk from farm to farm, and supply it to consumers in nearby towns or sell it to milk shops or merchants who transport the produce to cities farther away.
[2] Some studies have found that milk quality, measured in terms of fat content, depends on the end-use. Milk meant for making *khoya*, a buttery substance used to make traditional sweetmeats, had the highest fat content while the milk sold to urban teashops had the lowest fat content (Riaz, 2008). These changes occur within the milk supply chain, especially when milk reaches a milk shop or creamery, but not necessarily at the farmers' end. Nevertheless, farmers can influence milk fat content through choice of nutrition regime for their livestock.
[3] Milk procurement centers operated by commercial dairy firms are equipped with portable devices for measuring the milk's fat content. The firm offers one base price—usually for milk with a 6 percent fat content, which is typical of buffalo milk in Pakistan—which is adjusted upward or downward depending on the fat content of the milk sold by each individual farmer.

At present, however, the share of modern dairy firms in the overall milk supply is very small. Roughly, 97 percent of the milk produced is marketed through traditional channels, while the remaining 3 percent is procured and processed by commercial firms (Fakhar & Walker, 2006).[4] Among other things, the expansion of modern marketing channels' share in overall milk supply will depend on their competitiveness.[5] Traditional supply chains have lower overheads as, due to poorly enforced food safety regulation by the government, they do not invest in the supply chain infrastructure needed to preserve the quality of fresh milk.

To a considerable extent, therefore, the competitiveness of modern supply chains vis-à-vis their traditional counterparts depends on the former's ability to raise productivity. Some large dairy firms, including a vertically integrated dairy cooperative, provide development and extension services to member dairy farmers, which are financed by the profits from sales of UHT milk in urban markets.[6] However, not all large commercial dairy firms are cooperatives. Most provide little or no extension services support to farmers. They do, however, use pricing regimes that are based on measured milk quality (i.e., fat content).

We argue here that pricing based on measured milk fat content enhances efficiency because farmers respond by improving animal nutrition in an attempt to capture the quality premium, and in general make more judicious use of feed and fodders. We test this hypothesis by comparing the efficiency of dairy farmers who sell milk both through modern and traditional marketing channels in Punjab, Pakistan. Our findings provide qualified support for the hypothesis.

Section 2 describes the study area and milk marketing networks. Section 3 presents our methodology for nonparametric data envelopment analysis (DEA), specifies the follow-on econometric model, and describes the data used for the study. This is followed by the study's results and corresponding discussion in Section 4. Finally, Section 5 presents our conclusion and recommendations.

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[4] In Pakistan, the rate of growth of milk production by the commercial dairy processing industry is greater than that of fresh milk production. Thus, the industry's share has likely increased over time.

[5] Traditional supply chains thrive due to the poor implementation of government food safety regulations and consumers' preference for fresh milk and their lack of awareness about its quality.

[6] One example is the Idara-e-Kissan cooperative, which was originally started as a project with support from the German government (Riaz, 2008).

2. Milk Supply Chains in the Study Area

Our study area is located in district Sargodha in the west central part of the province of Punjab. According to the official livestock census in 2006 (Government of Pakistan, 2006), Sargodha's livestock population comprised 687,685 buffalos, 574,887 cattle, and about 2 million sheep and goats. The district is divided into six subdistricts called *tehsils*:[7] these include Sillanwalli, Bhalwal, Kot Momin, Sargodha (subdistrict), Sahiwal, and Shahpur. According to the district livestock office report (Bashir, 2009), commercial dairy firms procure about 117,000 liters of milk daily from different villages in Sargodha. Nestlé runs the largest set of procurement operations in the area, with a daily collection of 70,000 liters of milk. Other big companies, Noon and Haleeb, each procure over 20,000 liters a day.

In our sample, 43 farmers—30 from Sillanwali and 13 from Kot Momin—out of the 175 selected - sold milk directly to VMC centers of large commercial dairy firms, and received prices based on the measured fat content. The remaining farmers sold milk to traditional *dodhis*. In some cases, where commercial firms had collection centers in nearby villages, the *dodhis* supplied the milk they collected from the farmers to commercial firms. In these cases, however, the farmers did not receive prices based on measured milk fat content.

Recently, there has been growing interest in understanding how the existence of modern marketing networks influences dairy farming profitability and efficiency. For example, Riaz (2008) finds that members of Idara-e-Kissan—a vertically integrated cooperative that operates a milk modern supply chain and provides extension services—have had better returns to dairy farming compared to nonmembers. Wasim (2005) look at the responsiveness of Pakistani milk producers to price movements and calculated the elasticities of milk production. Burki and Khan (2008) investigate the impact of modern marketing channels on dairy farms' technical efficiency, using stochastic frontier analysis (SFA). Their main findings are: (1) Providing access to milk supply chain networks increases efficiency, (2) Dairy farms located in milk districts achieve the same output levels while using fewer inputs than farms not located in such districts, (3) Infrastructure is an important determinant of efficiency: farms located farther away from built roads are less efficient but the reverse is true for farms located in a milk district, and (4) Farms with larger herds are more efficient than farms with smaller herds, and the

[7] A *tehsil* is an administrative unit within a district. It usually comprises one main town that serves as the *tehsil* headquarters, a few smaller towns, and several villages.

positive impact of herd size on efficiency is augmented if the farm is located in a milk district.

The next section reviews various methodological approaches to the measurement of efficiency. We propose using a two-stage semi-parametric DEA technique to measure efficiency within a multi-output-multi- input framework.

3. Methodology and Data

As mentioned above, we use a semi-parametric DEA approach to assess the efficiency of dairy farmers with access to different marketing channels. The key advantage of DEA is that it does not involve arbitrary assumptions about functional form (Goncalves, Vieira, Lima, & Gomes, 2008). Several recent studies have conducted DEAs for agricultural and dairy sectors. Javed, Adil, Javed, and Hassan (2008) use the DEA method to study rice-wheat farming systems in Pakistan; Kulekci (2010) does the same for oilseed sunflower farms in Turkey; Coelli, Rahman, and Thirtle (2002) for rice farming in Bangladesh; Dhungana, Nuthall, and Nartea (2004) for rice farming in Nepal; Rios, and Shively (2005) for coffee growing in Vietnam; and Kamruzzaman, Manos, and Begum (2006) for wheat farming in Bangladesh.

Other studies have estimated the technical efficiency of the dairy sector. Goncalves et al. (2008) use DEA to measure the technical efficiency of dairy farms in Minas Gerais, Brazil. They find that larger farms are more technically efficient, but that this is due to better access to credit, technical support, and training. Smaller farms show increasing returns to scale (IRS), indicating that there is scope for increasing efficiency by adopting the optimal scale of operations.

Jaforullah and Whiteman (1999) have analyzed the technical efficiency of the New Zealand dairy industry. Using DEA, they find the mean technical efficiency (variable returns to scale [VRS]) to be 89 percent and scale efficiency (SE) to be 94 percent. More than half of the dairy farms in their sample were operating on a suboptimal scale. In addition, Burki and Khan (2008) use SFA to analyze dairy farms' technical efficiency. Their findings have already been discussed in the previous section.

3.1. Technical Efficiency

Farrell (1957) developed the concept of efficiency measurement at the micro-level (as cited in Forsund & Sarafoglou, 2002). Charnes, Cooper, and Rhodes (1978) use Farrell's conceptual framework to measure efficiency by formulating and solving a linear programming problem under the assumption of constant returns to scale (CRS). Banker, Charnes, and Cooper (1984) extend the model to VRS. Such models are known as DEA models.

3.1.1. Data Envelopment Analysis

The DEA approach involves determining to what extent the firm's input vector can be contracted while keeping its output level the same (input orientation), or to what extent the output vector can be expanded while keeping input levels the same (output orientation). For this purpose, the firm's actual input-output choices are compared with an external benchmark—the efficient frontier, which is formed by taking linear combinations of the best-practice input-output choices of other firms.

The linear programming technique is used to arrive at measures of potential input savings or output gains. It uses a piece-wise linear efficient frontier to represent technological possibilities. Efficient firms lie on the frontier and inefficient firms lie below it. Computing an individual firm's distance from the frontier is a deterministic exercise since the linear programming formulation does not allow the inclusion of stochastic terms in the model. It is typical for nonparametric DEA to be followed in the second stage by a parametric regression (e.g., based on a Tobit model) to determine the impact of farmer characteristics and environmental variables on technical efficiency.

The idea of comparing a firm's input-output choices against a best-practice frontier is not unique to DEA. There are other econometric approaches, such as SFA, that can achieve the same objective. Apart from postulating a parametric frontier, SFA also assumes that there is a stochastic component represented by the error term. The error is composite and consists of pure white noise as well as a component assumed to be drawn from a half-normal or truncated distribution. The latter can only take negative values and represents the distance of an inefficient firm from the frontier. SFA allows for the inclusion of environmental variables and joint estimation of their impact—along with the identification of frontier function parameters—on technical efficiency.

The main advantage of DEA is that it is nonparametric. That is, the results do not depend on assumptions about the functional form of a firm's unknown technology, or on those regarding the particular probability distributions of the stochastic component. The cost of avoiding arbitrary assumptions is that DEA efficiency scores cannot be used for the purposes of statistical inference because they are nonstochastic. By contrast, SFA postulates parametric production technology and a probability distribution for the stochastic error term.[8] The estimated parameters of the frontier, therefore, have standard errors that can be used to construct confidence intervals and test hypotheses. Both DEA and SFA have been extensively used in the literature on the measurement of technical efficiency. This study employs DEA to analyze the technical efficiency of dairy enterprises.

Under CRS technology, the DEA efficient frontier is a ray from the origin.9 To be on this frontier, a large firm has to maintain the same output-input ratio as its smaller counterpart. An important consideration is whether, as firms expand, they can realize output increases in the same proportion as increases in inputs. If this is not technically feasible and firms vary greatly in terms of the size of operations, then the use of CRS technology would make larger firms appear more inefficient than smaller firms.

A conical technology set would not be an appropriate choice in such cases. When all firms are not at the optimal scale of operations, CRS technical efficiency measures are confounded by scale efficiencies (SEs) (Coelli, Rao, O' Donnell, & Battese, 2005, p. 172). The problem can be resolved, however, by postulating VRS technology, which replaces the CRS conical hull with a convex hull that envelops the observed data more tightly.

3.1.2. The DEA Model

Following Coelli et al. (2005), the DEA model under VRS used to estimate technical efficiency is specified as follows:

$$\min_{\theta\lambda} \theta$$

$$\text{subject to} \quad -y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

[8] Commonly used functional forms for the efficient frontier include the Cobb-Douglas and translog forms.

[9] The corresponding technology set is a cone.

Here, y_i is an m x 1 vector of output of the ith firm, and x_i is a k x 1 vector of inputs of the ith firm. Y is an n x m matrix of outputs for n firms, and X is an n x k matrix of inputs for n firms. The parameter θ is the efficiency score of the ith firm. If θ is equal to 1, then the firm lies on the boundary of the input possibilities set, and is considered efficient. The parameter λ is a vector (n x 1) whose value is calculated to achieve an optimum solution. These values determine the weights assigned to the input vectors of all other firms that form the piece-wise linear efficient frontier for measuring the efficiency of the ith firm (Goncalves et al., 2008).

The technical inefficiency of a firm may be due partly to its suboptimal scale of operations. DEA technical efficiency scores can be decomposed into pure technical inefficiency and scale inefficiency. This requires computing both CRS and VRS efficiency scores. The difference between the two scores, if it exists, indicates that the firm in question is operating at an inefficient scale.[10] The SE measure is obtained as the ratio of technical efficiency scores under CRS and VRS, respectively:

SE = TE CRS/TE VRS

3.1.3. *Tobit Regression*

To understand the determinants of technical efficiency, we regress our DEA efficiency scores on several explanatory variables, representing farmer and herd characteristics, as well as milk marketing channels. Because the DEA scores necessarily lie between 0 and 1, we use a double-truncated Tobit regression (see for example, Wossink & Denaux, 2006). The Tobit model specification is as given below:

$$y_i^* = \beta_0 + \sum_{j=1}^{k} \beta_i x_i + u_i \qquad u_{i\sim} IN(0,\sigma^2)$$

Here, y_i^*, the DEA efficiency score for farmer i, is considered a latent variable, and the vector x_i (i = 1, … k) represents explanatory variables such as farmer and herd characteristics, and other environmental variables, such as access to modern marketing networks, that influence technical efficiency. The observed variable is y_i such that

$$y_i = 0 \text{ if } y_i^* \leq 0;\ y_i = y_i^* \text{ if } 0 \leq y_i^* \leq 1;\ y_i = 1 \text{ if } y_i^* \geq 1$$

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[10] In a single-output-single-input model, DEA scale inefficiency can be measured roughly as the ratio of average products evaluated at the projection of a firm's input-output combination on the boundary of the VRS convex hull, and at the optimum scale of operations. For more detail and graphical representation, see Coelli et al. (2005, p. 174).

3.2. Data and Variables Used

The data for this study was collected through interviews with 175 dairy farmers in the six *tehsils* of Sargodha district during May–July 2009. In the first stage, villages were selected from Sargodha district. Village selection was purposive because the study's objective was to assess the impact on dairy farmers' technical efficiency of modern marketing networks whose spatial coverage was highly nonuniform within the Sargodha district. Therefore, selecting villages randomly would not have been considered appropriate.

The criteria for village selection included: (i) the existence in the village of a VMC center operated by a commercial dairy firm, (ii) the existence of such centers in the area but not in the village, (iii) proximity to the nearest urban area, and (iv) remoteness of village location from transport and modern marketing networks. In each selected village, a list of farmers was drawn up with the help of local resource persons, and a sample of about 30 farmers was randomly drawn from this list to be interviewed. A secondary list of ten farmers was also prepared. If the originally selected farmer was not available, he was substituted with a farmer from the secondary list.

A detailed questionnaire was developed and pretested before being administered to each dairy farmer. The questionnaire collected information about the farmer's characteristics, the operational details of the farm, the composition of the dairy herd, input use and output decisions, and milk marketing arrangements.

3.2.1. Variables for DEA

Our DEA model is constructed using three output and seven input variables. Outputs include: the amount of total milk produced per year, the number of animal units sold per year, and the amount of animal dung produced per year. Inputs comprise: fodder area in the *rabi* (winter) and *kharif* (summer) seasons, the amount of feed concentrate used per year, the amount of balanced feed *vanda* used per year, the annual total value of other miscellaneous feed inputs,[11] the annual total number of hours worked by permanent hired labor and family labor, the annual user cost of livestock capital, and the number of in-milk and milch animal

[11] These included mostly salts as well as fiber in the form of wheat bran and chaff.

units on each farm.[12] The descriptive statistics for the variables used in the first-stage DEA are given in Table 1.

3.2.2. Variables for Follow-Up Tobit Analysis

The second stage of the study focuses on the determinants of technical efficiency. The variables considered are: education, dairy farming experience, operational area of farm, and size of dairy herd (see bottom panel of Table 1). To test the hypothesis regarding efficiency differences between traditional and modern marketing channels, we introduce a dummy variable representing milk marketing through the modern channel, which assumes a value of 1 if the dairy farmer sells milk directly to a modern marketing channel and 0 otherwise.

Table 1: Descriptive Statistics

Variables	Mean	Std. dev.	Min.	Max.
Outputs				
Milk production/ year (l)	8,468.4	9,020.3	730.0	55,115.0
Animals sold/year (standard livestock units)	1.1	1.5	0.0	5.8
Dung produced/year (kg)	21,712.2	15,563.3	2,190.0	75,737.5
Inputs				
Feed concentrates use/year (kg)	1,568.7	2,094.9	0.0	9,000.0
Balanced feed (*vanda*) use/year (kg)	646.8	2,695.3	0.0	26,640.0
Other feed expenditures/year (Rs)	34,771.8	40,680.6	0.0	306,600.0
Fodder area (*rabi*, winter) (acres)	3.1	2.7	0.06	13.0
Fodder area (*kharif*, summer) (acres)	3.4	3.1	0.03	16.0
Labor hours per year	2,863.9	1,414.9	456.3	7671.1
In-milk animals in the herd (standard livestock units)	3.4	2.7	0.7	14.8
User cost of livestock capital (Rs)	5,977.7	5,365.3	401.3	39,030.0
Farmer and dairy herd characteristics				
Education (years)	6.3	4.7	0.0	16.0
Experience (years)	22.7	13.9	1.0	60.0
Operational area (acres)	10.6	10.4	0.0	52.9
Herd size (standard livestock units)	11.6	8.3	0.7	41.2

Source: Authors' calculations.

[12] The term "in-milk animals" refers to cows and buffaloes in the dairy herd that are currently producing milk. Milch animals are cows and buffaloes regardless of whether or not they currently produce milk. The numbers of both types of animals are converted to standard livestock units.

4. Results and Discussion

4.1. Technical Efficiency

Table 2 presents sample average technical efficiency scores under CRS and VRS, as well as SE scores. When we assume technology to exhibit CRS, the average technical efficiency score of the sampled dairy enterprises is 0.84. Assuming that the reference technology shows VRS yields a sample average efficiency score of 0.89, which allows the technological frontier to exhibit a less-than-proportionate output increase with a radial expansion in all inputs.

Under the VRS assumption, the inefficient firms are benchmarked against firms of similar size (Coelli et al., 2005). The sample farmers are seen to be 16 percent inefficient on average under more restrictive CRS, but only 11 percent inefficient under VRS. The convexity restriction implied by the VRS assumption leads to lower estimates of inefficiency. Thus, depending on the assumed reference technology, the sampled dairy farmers could reduce input use by 11–16 percent on average, without reducing their output.

Table 2: Technical and Scale Efficiency Scores

Returns to scale	Technical efficiency score
Constant returns to scale	0.84
Variable returns to scale	0.89
Scale efficiency	0.94

Source: Authors' calculations.

The overall scale efficiency of the sampled dairy farms is 0.94 as indicated by the last row of Table 2. This implies that a 6 percent increase in output is possible on average if optimum-scale operations are adopted. SE seems to be a problem for smaller farmers. This is clearly seen in Table 3, which presents returns to scale by the size of dairy operations.

Table 3: Returns to Scale by Size of Dairy Operations

Returns to scale	Larger herds	Smaller herds
Constant returns to scale	48.15	39.46
Decreasing returns to scale	40.74	10.20
Increasing returns to scale	11.11	50.34
Total	100.00	100.00

Note: Smaller herds are defined as comprising fewer than 20 heads of livestock.
Source: Authors' calculations.

Over half the smaller dairy herds appear to be operating on IRS. These dairy operations could, in theory, increase their efficiency level by expanding their scale of operations. In practice, however, their small landholdings and (possibly) credit constraints do not allow them to maintain an optimum herd size.[13]

4.1.1. Determinants of Technical Efficiency

This section explores the determinants of technical efficiency. A number of farmer characteristics and herd characteristics are used as explanatory variables in a Tobit regression with DEA efficiency scores as our dependent variable. The Tobit model is estimated using the QLIM procedure in SAS software. The results are presented in Table 4.

Table 4: Follow-Up Tobit Regression

Parameter	Estimate	Standard error	t-value	p-value
Intercept	1.0572	0.0637	16.58	<0.0001
Education	-0.0129	0.0050	-2.54	0.0112
Dairy farming experience	-0.0019	0.0015	-1.22	0.2209
Operational land area	-0.0052	0.0023	-2.25	0.0247
Herd size	0.0091	0.0031	2.86	0.0042
Modern marketing channel	0.1160	0.0504	2.30	0.0216

Source: Authors' calculations.

[13] The landholding constraint is binding for small dairy farmers because livestock in the study area were stall-fed, requiring farmers to allocate land to fodder crops that then compete directly with land allocations for food and cash crops. Some farmers buy fodder from other farmers but because fodder needs to be harvested daily and chopped up before being fed to the animals, such purchases can only take place from nearby farmers. Moreover, credit constraints can prevent smaller farmers from acquiring livestock heads, or force them to liquidate part of the herd to meet emergency expenditures.

Farmers' level of education appears to be negatively related to their technical efficiency scores, and the effect is statistically significant. We include the squared education term to check for nonlinearity with respect to this effect. The squared education term is not significant in any alternative specification. This result is robust whether or not we include a modern marketing channel dummy in the model (see Table A2 in the Appendix). Moreover, the coefficient of the education variable remains negative and significant. The coefficient of dairy farming experience is not significant. This result is also robust to introducing the squared experience term into the model and, moreover, the squared term itself is not statistically significant.

Table 4 suggests that, as a farmer's operational land area increases, dairy farming technical efficiency falls. The coefficient of the operational land area variable is significant at less than 5 percent. This is hardly surprising because farmers with more land tend to grow more cash crops and, in the process, divert labor and managerial resources away from dairy farming operations. Interestingly, an increase in herd size has the opposite effect. The coefficient of the herd size variable is positive and statistically significant at 5 percent.[14] This corroborates our earlier conclusion that many smaller dairy enterprises operate below optimal scale. We can interpret the positive and statistically well-determined coefficient of herd size to imply that farmers with larger herds are able to operate near optimum scale, which enhances both their SE as well as overall technical efficiency.

An important objective of this study was to analyze the impact of access to modern marketing channels on the technical efficiency of dairy farms. Earlier, we hypothesized that access to modern marketing channels—where milk pricing is based on measured milk quality—raises dairy farmers' productivity because it induces them to improve animal nutrition in the attempt to capture a better price.

We test this hypothesis by including in the Tobit regression a dummy variable representing access to modern marketing channels (defined as those through which farmers sell milk directly to the

[14] It is possible to argue that herd size is endogenous in the sense that farmers who are more productive are able to raise and maintain larger herds. In the Sargodha district, livestock is mostly stall-fed. Farmers thus have to allocate adequate areas for fodder in each season, which competes with other land uses such as for food and cash crops. Since the land constraint is binding, herd size is determined largely by farm area. While technical efficiency can be changed by better allocation of inputs even in the short run, changes in a farm's operational area can occur only in the long run. Farm size is largely predetermined and, therefore, not endogenously determined by technical efficiency.

collection center of a commercial dairy firm that measures milk fat content and adjusts prices paid accordingly). Farmers selling through other intermediaries are not considered to be accessing a modern channel even if the intermediary subsequently supplies milk to a commercial dairy and is paid a price based on measured fat content. The logic of making this distinction is that only farmers who sell directly to commercial firms are likely to respond to milk quality premiums by adjusting their animals' nutrition. Table 4 shows that the coefficient of the variable representing access to modern marketing channels is positive and statistically significant with a p-value of 0.022. This provides qualified support to our hypothesis that access to modern marketing channels (that pay dairy farmers based on measured milk quality) raises the technical efficiency of dairy farming.

An important consideration in investigating the relationship between modern marketing channels and technical efficiency is the potential for self-selection.[15] If the more productive farmers self-select themselves into modern supply chains, then the Tobit regression results reported above could suffer from an endogeneity bias. For a serious endogeneity problem to arise, however, it must be true that self-selection is costless or that at least the transaction costs associated with it are very low.

For our sample, the requirement of zero or low transactions associated with self-selection is not met because of the nonuniform spatial density of modern supply chain networks.[16] These networks do not extend to all remote areas. Farmers in un-serviced remote areas have no recourse except to sell milk to traditional market intermediaries. Moreover, modern supply chains are also absent from peri-urban areas where the traditional intermediaries, who sell fresh milk in the nearby city, enjoy a cost advantage over large commercial firms that have to first transport fresh milk to their distant processing plants and then ship the processed milk and milk products back to cities and towns.

That the farmer's choice of market intermediary is substantially influenced by the transaction costs associated with milk delivery can be seen in Table 5. The table shows that, almost without exception, farmers who did not report the presence of a VMC point in their village, sell milk to traditional *dodhis*. Interestingly, some of these villages are located in

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[15] We are grateful to an anonymous referee for making this point.

[16] Modern supply chain infrastructure for fresh milk is expensive to build because it requires setting up chillers and establishing village milk collection centers, and there are costs associated with transporting milk over long distances between collection centers and firms' processing plants.

milk districts, but the transaction costs associated with supplying milk to a VMC point located in another village in the district seems to be high enough to cause farmers to opt against self-delivery.[17]

Table 5: Location of VMC and participation in marketing channels

Choice of market intermediary	VMC centre located in village	Frequency	Percent
Modern	Yes	42	100.00
	No	0	0.00
Traditional	Yes	1	0.76
	No	131	99.24

Source: Authors' calculations.

For villages that had VMC points, the reported average distance ranged between 700 and 800 m or roughly 1.5 km for a roundtrip. This is the distance a farmer could cover without great difficulty, usually on foot, if delivering milk to a VMC point once or even twice a day.[18] Table 5 underscores that the location of a VMC point in the village is a necessary condition for participation in a modern marketing channel.

The results reported above suggest that the existence of modern supply chains is linked to a higher technical efficiency score for dairy farming operations. Moreover, the foregoing discussion also suggests that the self-selection problem may not be so severe as to warrant an outright rejection of causality running from modern supply chain networks to higher technical efficiency.

While the results of the Tobit model reported in Table 4 need to be interpreted cautiously, in our view, they provide some weak support to the hypothesis that direct access to modern supply chains could have a positive impact on efficiency. The qualification that access is direct is important because only under this arrangement can the existence of milk quality premiums be adequately signaled to farmers, who would then respond by improving animal nutrition to capture those premiums.

[17] The most plausible explanation for this is economies of scale in transportation. An individual farmer's marketable surplus for milk is small. Mobile *dodhis* collect milk from several farmers at a time and supply it to shops in towns or to modern supply chain collection points located in other villages in the milk district.

[18] This also suggests that farmers who live on *deras* farther away from the village cannot participate in the modern marketing channel even when the VMC is located in the village.

It is pertinent to mention that, as in our model, Burki and Khan (2008) have also used a dummy variable in their stochastic frontier to represent modern marketing channels. They conclude that building milk supply chains increases the technical efficiency of dairy farms, and our results are consistent with their findings.

5. Conclusion

Our results indicate that the average technical and scale efficiency scores of the sampled dairy farms overall are 0.89 and 0.94, respectively. Smaller herds are more likely to be operating at suboptimal scale. The follow up Tobit analysis of the determinants of technical efficiency provides qualified support for our main hypothesis that (i) access to modern marketing channels (milk is priced by measured fat content) increases technical efficiency; and that (ii) farmers sell milk directly to a modern supply chain's collection point. The mere coverage of an area by modern milk marketing networks does not enhance efficiency per se because indirect sales to modern channels through market intermediaries do not give farmers the incentive to alter animal nutritional practices and try to capture milk quality premium.

We recognize that there are possibilities for at least some farmers in the sample to self-select into modern supply chains. But, in our view, such possibilities are very restricted because of the nonuniform spatial density of modern supply chain networks and the existence of significant transaction costs. Therefore, our findings can be cautiously interpreted as providing some weak support for the hypothesis that direct access to modern supply chains may have technical efficiency-enhancing effects through provision of incentives to improve animal nutrition. Our findings underscore the need for further research on the relationship between productivity and contractual arrangements that involve built-in price incentives based on monitored milk quality (i.e., testing fat content and perhaps other attributes).

The results also suggest that farmers with larger dairy herds are more technically efficient. However, farms with a larger land area score lower efficiency on average, possibly because they tend to specialize in crop agriculture. Likewise, the efficiency scores are inversely related to farmers' level of education. This counterintuitive result has to be interpreted against the backdrop of a very low education level among the sampled farmers (just over six years, on average). Dairy farming experience does not seem to be significantly related to farmer efficiency.

This study was limited to the Sargodha district, but its key hypothesis should be tested on a wider scale to draw conclusions for the dairy sector as a whole. Any such endeavor should involve drawing a larger sample that could more adequately represent a richer typology of both modern and traditional supply chains, and variations in agro-climatic conditions. The sampling design should address possibilities for self-selection by dairy farmers into various types of supply chain networks.

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Appendix

Table A1: Descriptive Statistics

Variables (Units per animal per year)	Mean	Standard dev.	Minimum	Maximum
Outputs				
Milk production (l)	2,349.19	984.20	486.67	6,123.89
Animals sold (standard livestock units)	0.44	0.75	0.00	3.84
Dung produced (kg)	7,626.11	5,207.75	2,190.00	49,840.75
Inputs				
Feed concentrates use (kg)	493.72	519.92	0.00	2,820.00
Balanced feed (*vanda*) use (kg)	154.19	461.08	0.00	3,000.00
Other feed expenditures (Rs)	12,496.41	11,791.87	0.00	59,250.00
Fodder area for rabi (acres)	1.15	1.06	0.02	6.75
Fodder area for kharif (acres)	1.24	1.10	0.01	5.50
Labor hours per year	1,214.21	837.43	273.75	5,858.25
User cost of livestock capital (Rs)	2,357.28	2,169.68	171.46	12,240.00

Note: All figures are in units per in-milk animal per year unless otherwise stated.

Table A2: Tobit Regressions (Alternative Specifications)

Parameter	Model 1	Model 2	Model 3	Model 4
Intercept	1.090303***	1.1123***	1.050695***	1.003065***
	(13.44)	(13.50)	(20.40)	(14.39)
Education	-0.028631*	-0.0274*	-0.023620*	-
	(-1.94)	(-1.82)	(-1.61)	
Education^2	0.001274	0.0012	0.001040	-
	(1.14)	(1.03)	(0.92)	
Experience	-0.002738	-0.0025	-	-0.001502
	(-0.53)	(-0.48)		(-0.28)
Experience^2	0.000011	0.0000095	-	0.000018
	(0.13)	(0.10)		(0.20)
Operational area	-0.005162**	-0.0055**	-0.005956**	-0.007066**
	(-2.23)	(-2.34)	(-2.52)	(-3.01)
Herd size	0.008956**	0.0095**	0.009500**	0.008890**
	(2.80)	(2.91)	(2.91)	(2.73)
Modern marketing channel	0.119040**	-	-	-
	(2.35)			

Note: T-values are given in parentheses. Asterisks ***, **, and * indicate 99, 95, and 90 percent significance level, respectively.

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The Impact of Gypsum Application on Groundnut Yield in Rainfed Pothwar: An Economic Perspective

Hassnain Shah[*], Muhammad Azeem Khan[**], Tariq Azeem[***], Abdul Majid[****], and Abid Mehmood[*****]

Abstract

This study presents an economic analysis of experimental on-farm data on the yield effect of gypsum on groundnut production in Pakistan's Pothwar region. The data indicates that groundnut pod yield increases significantly with the application of gypsum at 500 kg/ha for both local and improved (chakori) varieties of groundnut. The higher net benefits generate a marginal rate of return of up to 132 percent for local and 202 percent for improved varieties of groundnut. We carry out a sensitivity analysis and minimum returns analysis, and find, respectively, that the recommended application is capable of withstanding price variability and variability in yield. Since price structure changes more rapidly than technology, recommendations should be based on an analysis of returns under varying input and output prices.

Keywords: Groundnut, gypsum, economic analysis, rate of return, Pakistan.

JEL Classification: Q19.

1. Introduction

The groundnut (*Arachis hypogaea* L.) crop is one of the world's principal oilseeds. Until the mid-1980s, it ranked third after soybean and cottonseed, but has now been surpassed by rapeseed in terms of world production, closely followed by sunflower seed.[1]

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[*] Senior Scientific Officer, National Agricultural Research Centre (NARC) Social Sciences Institute in Islamabad, Pakistan.
[**] Senior Director, Social Sciences Institute, NARC.
[***] Research Officer, Barani Agricultural Research Institute, Chakwal, Pakistan.
[****] Country Officer, International Center for Agricultural Research in the Dry Areas (ICARDA), Islamabad, Pakistan.
[*****] Director, Barani Agricultural Research Institute, Chakwal, Pakistan.

[1] The emergence of rapeseed and sunflower seed may have been due to growing health concerns among industrialized countries and to European Union policy.

The crop's high content of edible oil (50 percent) and protein (25 percent) makes it a popular human food. It is consumed either as a shelled nut or in the form of edible oil after the kernel has been pressed, or in a range of other forms subject to various degrees of processing such as peanut butter, sauce, flour, or confectionery items. Groundnut cake or flour is a valuable ingredient in developing countries where diets often consist mainly of low-protein cereals. It is also a good source of minerals such as phosphorus, calcium, magnesium, and potassium, as well as vitamins E, K, and B. In many countries, "groundnuts are not used for oil, …, but are consumed locally, either fresh, roasted, or as nutmeats added to sweets" (Brookes, Ahmad, & Hussain, 1988). Additionally, groundnut haulms, whose feed value is similar to that of lucerne seed, are used as animal feed (Ahmad & Rahim, 2007; Nath & Alam, 2002; Raw Materials Research and Development Council [RMRDC], 2004). The groundnut is thus one of the most important legume crops and, moreover, enriches the soil with nitrogen without draining nonrenewable energies or upsetting the agro-ecological balance (Khan, Faridullah, & Imtiazuddin, 2009; Reddy & Kaul, 1986).

Production by developing countries accounts for over 95 percent of the total area under groundnut cultivation, and about 94 percent of total production, most of which is concentrated in Asia and Africa. In Pakistan, groundnut is cultivated mainly in rainfed areas—about 84 percent of the total groundnut area lies in Punjab, 13 percent in Khyber Paktunkhwa, and 3 percent in Sindh (Government of Pakistan, 2008). Table 1 gives the area and production of groundnut for 2005–2010.

Table 1: Area, production, and groundnut yield in Pakistan

Year	Area ('000 ha)	Production ('000 tonnes)	Yield (tonnes/ha)
2005	93.71	69.13	7.38
2006	93.50	73.90	7.90
2007	94.90	83.40	8.79
2008	92.80	85.50	9.21
2009	87.40	53.20	6.09
2010	88.00	63.00	7.16

Source: Retrieved from http://faostat.fao.org on 24 March 2012.

Of the total area under peanut cultivation, 83 percent lies in the Pothwar tract, which contributes 71 percent to the country's total production (Government of Pakistan, 2008). It is considered a cash crop in the rainfed regions of Punjab (Hussain & Ahmed, 1984). The Pothwar

Plateau comprises mainly the districts of Rawalpindi, Chakwal, Attock, and Jhelum—an area of over 1 million ha. As a rainfed tract, it accounts significantly for Pakistan's agriculture and livestock production (Supple, Saeed, Razzaq, & Sheikh, 1985).

The environment in which groundnut is grown (the Pothwar tract) varies considerably in terms of patterns of precipitation and temperature (Hassan, Manaf, & Ejaz, 2005). Rainfall is erratic and varies greatly from 1,000 mm in the northeast to 250 mm in the southwest. The tract lies between 33.38 N and 73.00 E. About 70 percent of 1 million ha is cropped under cereals, mainly wheat, mustard, and chickpeas in winter, and maize, sorghum, groundnut, *mung*, and mash beans in summer (Hayat, 2005). Groundnut is grown generally in the drier southern part of the Pothwar (Ali, Schwenke, Peoples, Scott, & Herridge, 2002).

Among other agronomic factors, low-yield varieties and imbalanced nitrogen and phosphorus fertilization are the major constraints to the yield gap of groundnut in Pakistan. In *barani* cropping patterns, low soil fertility is considered one of the most important problems causing low yield (Khan et al., 1989). In general, soil fertility and organic matter content (0.2–1.2 percent) in *barani* tracts is low (Ahmad, Davide, & Saleem, 1988). The nitrogen content of the organic fractions of rainfed soils is merely 0.03–0.07 percent (Smith, Walls, Rehman, & Nawaz, 1991), and this is a major factor accounting for inefficient water use and low crop yields in the country's rainfed areas (Khan, Qayyum, & Chaudhary, 1989).

A multidisciplinary team from different national and provincial agricultural research institutions was organized to address these agricultural productivity issues and, during the course of its work (2001–2007), also developed and validated a number of groundnut production technologies at the integrated research sites of the Barani Village Development Project (BVDP) in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA).

Farmers adopt different components sequentially using economic and other relevant criteria of their choosing (Byerlee & de Polanco, 1986). Agronomic data only establishes the technical relationships that can be used to determine a technical optimum. This has been done for wheat by Anwar, et al. (2005), for cotton by Javed, et al. (2009), and potatoes by Abedullah, et al. (2006). The "economic optimum" for any input is always lower than the "technical optimum." Thus, it is necessary for biological scientists to conduct economic analyses in a similar manner as they are responsible for the statistical analysis of their trials. The usefulness of the results of many biophysical research experiments can be greatly enhanced if the relevant economic analyses can be applied to the results. In this regard, therefore, it makes sense for biological scientists and agricultural economists to jointly evaluate experiments to establish both biological and economic viability.

This study's purpose, therefore, is to contribute to this learning process by developing farm input recommendations that could be useful particularly for multidisciplinary research teams involved in on-farm testing and for policymakers concerned with investment in the dissemination of new technologies based on their rates of return.

Section 2 describes the study's sources of data in the context of the literature and background of the project from which the data has been drawn, and explains the methodology used to analyze this data. Section 3 explains the different techniques of analysis used to assess input recommendations. Section 4 presents and discusses the study's results, Section 5 draws some key policy implications, and Section 6 concludes the article.

2. Data and Methodology

Farmers' criteria to evaluate and adopt technologies may be entirely different from that of researchers, and returns on investment in agricultural research cannot be achieved unless farmers adopt researchers' recommendations. Agricultural economists have developed theories and methods of analysis to address the issue of risk—utility analysis (Dillon, 1971) and risk analysis (Anderson, Dillon, & Hardaker, 1977; Hardaker, Huirne, Anderson, & Lien, 2004). One approach to developing recommendations for farmers has been to draw on standard production economic theory (Doll & Orazem, 1984), consider the likely returns on funds invested in new technologies, and ask the question, "What is the likely minimum return on investment (ROI) or marginal rate of return (MRR) that would be necessary for a particular technology to appeal to farmers given that there is variability in likely returns and that they are risk averse?"

This approach was considered particularly useful for farmers in developing countries (International Maize and Wheat Improvement Center [CIMMYT], 1988). Accordingly, using the CIMMYT's approach, we use on-farm experimental data generated by the Barani Agricultural Research Institute (BARI) in Chakwal, Pakistan, at two research sites under the

BVDP, to develop farm input recommendations aimed at providing valuable information to decision makers in an investment context.[2]

The data from the research trials conducted at the BVDP's two integrated research sites was provided by BARI, which, in turn, was involved in the applied research. Here, we analyze 26 replications of the *chakori* variety, and 17 replications of the local (farmers' fields) variety. Each selected farmer's field is considered a replication for every year of technology validation, and we have tried to select fields with more or less homogeneous conditions with respect to soil type and fertility level. Most fields were 1 acre large, and contained both experimental and control treatments so that the effect of external factors—particularly variations in soil or moisture, etc.—was equally distributed between the two treatments. The farmers themselves carried out all operations with no difference other than the treatments under study. Information on the prices of inputs and output from the same area was collected during collaborative work at the research sites, while data on gypsum prices was gathered through market surveys conducted among input dealers.

The research trials were conducted systematically and scientifically from site selection, diagnostic analysis, baseline survey, and ongoing trial assessment at farmers' fields. The basic assumptions of conducting diagnostic studies to identify the major constraints to farm productivity and to understand farmers' agronomic and socioeconomic conditions (see Boughton, Crawford, Krause, & de Frahan, 1990) were fulfilled. Moreover, the procedures assume that the level of net benefit is an important criterion for farmers when they evaluate alternative technologies. An extensive exercise carried out allowed for the selection of representative sites so that the research findings could be extrapolated onto a large representative area. The assumption of homogeneous sites on which to conduct an economic analysis of pooled data is, therefore, also valid (see Shah, Khan, Akmal, & Sharif, 2005).

In general, two apparently distinct types of peanut (*Arachis hypogea*) are grown commercially. One is upright with an erect central stem and vertical branches, while the other is recumbent with numerous creeping laterals (Hassan et al., 2005). On-farm trials of the application of gypsum to

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[2] A number of studies have used the same methodology to conduct economic analyses of experimental data, including Agbaje, Saka, Adegbite, and Adeyeye (2008); Asumadu, Sallah, Boa-Amponsem, Manu-Aduening, and Osei-Bonsu (2004); Demeke (1999); Dillon and Hardaker (1993); Saka, Adeniyan, Akande, and Balogun (2007); Shah, Hussain, Akhtar, Sharif, and Majid (2011); and Shah, Sharif, Majid, Hayat, and Munawar (2009).

both the improved or *chakori* variety with vertical branches, and to the local variety with creeping branches, were conducted at farmers' fields at two sites—Hafizabad in district Attock and Jarmot Kalan in district Rawalpindi—from 2002 to 2005. The data was generated to assess the crop's response to gypsum application at the rate of 500 kg/ha at the flower initiation stage along with control treatment with no gypsum application. Since the technologies were being validated on-farm after proper testing and evaluation at research stations, only that input level that proved promising was further evaluated at farmers' fields.[3]

3. Analysis Techniques

3.1. Partial Budget Analysis

We carry out a partial budget analysis to calculate gross field benefits (GB_f) as follows.

$$GB_f = P_f \times Y_{adj}$$

P_f is the output's field price, defined as the value of 1 kg of the output to the farmer, and Y_{adj} is the adjusted yield of a treatment, i.e., the average yield adjusted downward to a certain percentage to reflect the difference between the experimental yield and the yield that a farmer could expect from the same treatment without the researchers' involvement.

We calculate the net benefit (NB) by first calculating the total costs that vary (TCV), using the field prices of inputs. TCV is the sum of individual costs that vary among different treatments whereas the field price of a variable input is the value that must be given up to bring an extra unit of input into the field. The NB is calculated as follows.

$$NB = GB_f - TCV \text{ .}$$

3.2. Marginal Analysis

There are four steps in a marginal analysis, identifying a candidate recommendation: (i) identifying and eliminating inferior treatments (dominance analysis), (ii) constructing an NB curve, (iii) calculating the MRR between treatments of incremental cost, and (iv) comparing MRR to the minimum rate acceptable to farmers (Boughton et al., 1990; CIMMYT,

[3] It could be very useful if researchers were to experiment and collect data at further levels for such experiments so that the marginal analysis could give a comparative picture of the rate of returns.

l988). We carry out a marginal analysis to calculate the MRR between the incremental NB (∂NB) and the treatments of incremental cost (∂TCV), and compare the MRR to the minimum rate acceptable to farmers using the following equation:

$$MRR = \frac{\partial NB}{\partial TCV} \times 100$$

In order to make recommendations based on the marginal analysis, it is necessary to estimate the minimum acceptable rate of return (M) to farmers in the recommendation domain. Experience and empirical evidence have shown that, for resource-poor farmers, the minimum MRR is typically 50–100% (CIMMYT, 1988; Erenstein, 2009; Makinde, Saka, & Makinde, 2007). A technology change with an MRR of less than 50 percent will not have many takers whereas a technology change with an MRR of more than 100 percent is likely to generate widespread interest (Erenstein, 2009). Usually, a minimum rate of return is fixed as the baseline for acceptance of an option in order to account for the cost of capital, inflation, and risk. In this regard, several studies have established that, in most situations, the minimum rate of return acceptable to farmers is 40–100 percent (Asumadu et al., 2004; CIMMYT, 1988; Dillon & Hardaker, 1993).

We set a minimum-rate-of-return criterion of 50 percent (see CIMMYT, 1988) for the MRR analysis, since the treatments require that farmers change from one cropping system to another without having to learn new skills or acquire new equipments. Consequently, farmers are likely to consider worthy of investment any treatment that generates an MRR above 50 percent. Regarding investments of a capital nature, the CIMMYT (1988) proposes that a minimum ROI of twice the cost of capital could be a relevant measure for capital investments in new technologies. Alternatively, especially for poor farmers in developing countries or for technologies requiring substantial change to a farming system, a minimum target ROI of 100 percent (the two-for-one rule) is likely more relevant in our case (Farquharson 2006; Shah et al., 2009).

3.3. Minimum Returns Analysis

Conducting a minimum returns analysis is a useful way of examining the variability associated with different technological alternatives. Looking at cross-year variability helps estimate the risks for farmers associated with the proposed recommendation. Minimum returns analysis does not look at averages, but rather at variability in the NB generated at individual sites. Farmers will prefer whichever treatment is more consistent. A minimum returns analysis compares the average of the lowest NB for each nondominated treatment. The NB at each location for each treatment is calculated as

$$NB = (Y \times A \times P_f) - TCV$$

where Y = yield at one location, A = 1 – yield adjustment, P_f = field price of output, and TCV = total costs that vary.

Approximately 25–30 percent of the lowest NB are selected for one treatment and compared with the 25–30 percent lowest NB of the alternative. If the average of the lowest NB for the tentative recommendation is higher than the lowest NB of the farmers' practice, then the recommendation is made because even in the worst cases, it does better than the latter.

3.4. Sensitivity Analysis

A sensitivity analysis of different interventions is conducted to test a recommendation's ability to withstand price changes, and essentially implies redoing a marginal analysis using alternative prices. It allows us to calculate the maximum acceptable field price of an input with the minimum rate of return:

$$\Delta TCV = \frac{P_f \times \Delta Y_{adj}}{1 + M}$$

where

$$\Delta TCV = \Delta q_i \times MP_i + t_i$$

ΔTCV = change in TCV, Δqi = change in variable input, t_i = cost of labor to apply variable input, MP_i = maximum acceptable price of variable input.

4. Results and Discussion

4.1. Net Benefit

In Table 2, we construct a separate partial budget for local and improved varieties of groundnut to calculate the net benefit of each, and compare farmer practice T1, i.e., without gypsum, and T2, i.e., with gypsum application. The results of the partial budget indicate that the use of gypsum generate the highest net benefit, both for the local and improved (*chakori*) variety of groundnut. In this case, the TCV only includes the cost of gypsum, its transportation, and application. Although the trials were conducted in a participatory manner, we have adjusted the yield to 10 percent lower to eliminate the advisory role of scientists. Our estimates use the 2004 price level for gypsum and groundnut, and the 2004 wage level.

Table 2: Partial budget analysis

	Local variety		**Improved variety**	
Partial budget	T1	T2	T1	T2
Pod yield (kg/ha)	1,043.3	1,185.4	1,175.6	1,360.4
Ad. yield (kg/ha)	939.0	1,066.8	1,058.0	1,224.3
Field price (PRs/kg)	726.0	726.0	726.0	726.0
Gross field benefits (PRs/ha)	17,043.2	19,363.5	19,204.0	22,222.1
Gypsum level (kg/ha)	0.0	500.0	0.0	500.0
Cost of gypsum	0.0	900.0	0.0	900.0
Cost of gypsum application	0.0	100.0	0.0	100.0
TCV	0.0	1,000.0	0.0	1,000.0
NB	17,043.2	18,363.5	19,204.0	21,222.1

Source: Authors' estimates.

4.2. Marginal Rate of Return

The results for the introduction of gypsum application to the local groundnut variety were found very satisfactory—the marginal NB was PRs 1,320.30 per ha with a marginal cost of PRs 1,000 per ha, resulting in an MRR of 132 percent. This is considerably high and makes the application of gypsum to the local variety of groundnut worth recommending. The improved variety also responded positively to the application of gypsum, with a higher MRR of 201.8 percent (the marginal NB was PRs 2,018 per ha with the same marginal cost of PRs 1,000 per ha). Our results show, therefore, that the farmer would gain an additional PRs 1.32 as returns on every one rupee invested in gypsum applied to the local groundnut variety, and an additional PRs 2.018 as returns on every one rupee invested in gypsum applied to the improved (*chakori*) variety. Thus, on the basis of marginal analysis, the technology appears to be highly profitable and should be recommended for wide-scale demonstration and adoption.

However, farmers would gain maximum benefits if they were to adopt the improved variety in addition to gypsum application.

The results of the marginal analysis are supported by the residual analysis, which is often used when there are more treatments with very little variation in the MRR. In that case, farmers are mostly interested in whichever treatment yields the highest residual value. The results of the analysis using residuals gives a similar picture, as the residual value is maximum for the treatment already recommended through marginal analysis.

4.3. Minimum Returns Analysis

Looking at cross-location and cross-year variability is one way of estimating risk for farmers associated with the proposed recommendation. The careful definition of recommendation domains attempts to eliminate cross-location variability as far as possible. Cross-year variability, however, is estimated here based on the results of only two or three years, and tends to underestimate the year-to-year variability that farmers face. Nevertheless, a careful minimum returns analysis is a useful way of examining the variability associated with different technological alternatives. It is worth noting that farmers are more interested in variability in benefits than variability in yields; a minimum returns analysis looks at variability in NB (CIMMYT, 1988).

Our study used comprehensive criteria to select representative sites at which to carry out the applied research and disseminate the project results across similar zones (see Shah et al., 2005) that would reduce cross-location variability while making the recommendation. The results of the minimum returns analysis of gypsum application to both local and improved groundnut varieties indicate that the average NB generated by the lowest 25–30 percent of replications is higher compared to the without-gypsum scenario. The average NB yielded by the lowest six of 17 replications that did not have gypsum applied to the local variety was PRs 8,270; the average NB with the application of gypsum was PRs 8,538 per ha.

In the case of the improved variety, the value of the NB of six of the 26 lowest-yielding replications was PRs 9,805 per ha without gypsum application, and PRs 10,447 per ha with gypsum application. The NB yielded even by the worst replication was higher in the case of gypsum application than the replication with minimum returns without gypsum replication. In the case of the local variety, only one replication resulted in a higher NB, but we can still conclude that gypsum application provides consistent results—it is less risky since the variation in returns from individual sites is smaller for both varieties of groundnut.

4.4. Sensitivity Analysis

Gypsum application at the rate of 500 kg per ha results in a higher adjusted yield of 128 kg per ha from the local groundnut variety. In our analysis, we have applied a higher price of gypsum (PRs 90 per 50 kg) to the study area, while the general market price of gypsum was PRs 40–50 per 50 kg in other areas in that year. This was due mainly to low demand and, consequently, less interest among gypsum dealers, resulting in low supply and high prices in the study area. The sensitivity analysis suggests that gypsum could be applied to increase the pod yield of local gypsum up to PRs 106.02 per bag while keeping the minimum acceptable rate of return at 100 percent. In the case of the improved variety, the change in adjusted yield was 166 kg per ha, which resulted in a maximum acceptable field price of PRs 140.90 per bag of gypsum, keeping the MRR at 100 percent.

Markets, inflation, and policies are generally too unpredictable for researchers to forecast prices with any certainty. Recommendations often involve an investment in extension agents' time, field days, pamphlets, or radio programs, and researchers would like to feel that a recommendation is likely to withstand any possible changes in the prices of inputs or crops for at least a few years. The best way to test a recommendation for its ability to withstand price changes is through a sensitivity analysis (CIMMYT, 1988).

Our analysis was carried out to define the range of maximum acceptable prices with varying output prices, keeping the minimum rate of return required by farmers equal to 100 percent (Table 3). Similarly, Table 4 shows the range of returns generated by different input prices when the output price is fixed; Table 5 indicates the varying prices of output when the input price is fixed. These results help anticipate the recommendation's validity and the possible returns on the specified domain under changing prices. On assessing these returns, farmers may decide to adopt different price scenarios. It also helps define the recommendation's potential given fluctuating market prices.

Table 3: Different input and output prices resulting in 100% MRR by variety

Groundnut variety			
Chakori (improved)		Local (farmer practice)	
Field price of groundnut (PRs/kg)	Max. acceptable field price of gypsum (PRs/kg)	Field price of groundnut (PRs/kg)	Max. acceptable field price of gypsum (PRs/kg)
15.00	2.29	15.00	1.72
18.15	2.82	18.20	2.12
20.00	3.13	20.00	2.36
25.00	3.96	25.00	3.00
30.00	4.79	30.00	3.64
35.00	5.62	35.00	4.27
40.00	6.45	40.00	4.91
45.00	7.28	45.00	5.55
50.00	8.11	50.00	6.19
55.00	8.95	55.00	6.83

Source: Authors' estimates based on data from the Barani Agricultural Research Institute.

Table 4: Returns under varying input prices keeping output price fixed

Groundnut variety			
Chakori (improved)		Local (farmer practice)	
Price of gypsum (PRs/kg)	MRR	Price of gypsum (PRs/kg)	MRR
3.82	0.50	2.89	0.50
3.25	0.75	2.45	0.75
2.82	1.00	2.12	1.00
2.48	1.25	1.86	1.25
2.21	1.50	1.66	1.50
1.99	1.75	1.49	1.75
1.81	2.00	1.35	2.00
1.66	2.25	1.23	2.25
1.52	2.50	1.13	2.50
1.41	2.75	1.04	2.75

Note: Field price of groundnut = PRs18.15/kg.
Source: Authors' estimates based on data from the Barani Agricultural Research Institute.

Table 5: Returns under varying output prices keeping input price fixed

Groundnut variety			
Chakori (improved)		Local (farmer practice)	
Groundnut price (PRs/kg)	**MRR**	**Groundnut price (PRs/kg)**	**MRR**
9.92	0.50	12.91	0.50
11.58	0.75	15.06	0.75
13.23	1.00	17.21	1.00
14.89	1.25	19.36	1.25
16.54	1.50	21.51	1.50
18.19	1.75	23.66	1.75
19.85	2.00	25.82	2.00
21.50	2.25	27.97	2.25
23.16	2.50	30.12	2.50
24.81	2.75	32.27	2.75

Note: Field price of gypsum = PRs2.00/kg.
Source: Authors' estimates based on data from the Barani Agricultural Research Institute.

5. Policy Implications

The analysis above provides a number of insights not only for researchers but also for extension agents and policymakers. The main implication is that the economic returns on the recommended investment play a key role in the adoption of technologies, which varies with changes in prices. Technologies are recommended on the basis of their technical optimum without considering the economic optimum under changing price scenarios. Hence, most technologies with a clear difference in yield are not adopted. Farmers' decisions regarding the adoption of a particular technology are backed by the level of returns under changing price scenarios over time and the associated risks. As agriculture becomes increasingly modernized, the relative significance of different factors affecting farm inputs and outputs changes; factors regarded as significant determinants of farmers' decisions at one time may not be relevant at others.

Knowing how farmers react to changes in market forces (Chaudhary, 2000 and Shah 2002) and government measures is important in different ways. The model provided in this study complements agronomic trials and thereby provides a useful tool to help define the technology potential, particularly in situations when the technology supply market is underdeveloped and its on-site price unknown or not necessarily representative of future adopters (see Erenstein, 2009). In developing recommendations, price and yield variability risks must be considered. An important implication of developing farm input recommendations when using economic analysis is that it helps extension agents—and ultimately farmers—in better decision-making. Such recommendations help farmers allocate their inputs more efficiently and effectively. Policymakers should thus focus on enhancing farmers' access to information by providing better extension services (see Javed, Adil, Hassan, & Ali, 2009).

6. Conclusion

The results of our economic analysis of experimental data provide sufficient evidence to recommend the application of gypsum to both local and improved varieties of groundnut—the MRR given the prevailing market prices of gypsum is above 100 percent and would be feasible even if the field price were to increase from PRs 90 to PRs 106 per bag for the local and PRs 141 per bag for the improved groundnut variety. The recommended input also appears capable of withstanding variability and risk considerations as shown by the minimum returns analysis and sensitivity analysis. A market survey of input dealers in the area indicates that gypsum was already being sold at very high prices. Its wholesale price was just PRs 45–50 per bag, but few input dealers were trading in gypsum because of its high storage cost vis-à-vis low demand.

If the recommended technology is widely demonstrated, it may help increase its demand, in turn attracting investors and developing competition, resulting in a decrease (competitive pricing) in the price of gypsum. This may further increase the returns to farmers since the MRR would likely rise. Additionally, an analysis delineating the returns under varying input and output prices and maximum acceptable field prices of gypsum under changing output prices would provide a useful guideline for future users adopting this technology.

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The Determinants of Food Prices in Pakistan

Henna Ahsan,* Zainab Iftikhar, M. Ali Kemal*****

Abstract

Controlling prices is one of the biggest tasks that macroeconomic policymakers face. The objective of this study is to analyze the demand- and supply-side factors that affect food prices in Pakistan. We analyze their long-run relationship using an autoregressive distributed lag model for the period 1970–2010. Our results indicate that that the most significant variable affecting food prices in both the long and short run is money supply. We also find that subsidies can help reduce food prices in the long run but that their impact is very small. Increases in world food prices pressurize the domestic market in the absence of imports, which cause domestic food prices to rise. If, however, we import food crops at higher international prices, this can generate imported inflation. The error correction is statistically significant and shows that market forces play an active role in restoring the long-run equilibrium.

Keywords: Food prices, ARDL estimation, Pakistan.

JEL Classification: E64, Q11.

1. Introduction

For macroeconomic policymakers, price control is one of their biggest tasks, but it is made all the more difficult when food prices rise more than usual,[1] given the number of external, structural, and demand factors involved in maneuvering food prices. Among others, these factors can include international food prices, subsidies, and the quantity of food crops produced in a particular year and previous years.

According to Trostle (2008), the world market prices of major food items such as vegetable oil and food grains—two essential items used in every household—have increased sharply by more than 60 percent in just two years. Chaudhry and Chaudhry (2008) cite World Bank data that reports an 83 percent increase in food prices during 2005 and 2008. Thus,

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* Staff Economist, Pakistan Institute of Development Economics (PIDE), Islamabad, Pakistan.
** Staff Economist, PIDE, Islamabad, Pakistan.
*** Research Economist, PIDE, Islamabad, Pakistan.
[1] The food consumer price index (CPI) constitutes 40 percent of the overall CPI basket (Janjua, 2005).

the rise in food prices is of great concern for policymakers because it directly affects the poor and below-average-income families, a significant proportion of whose income is spent on food. The authors also find that a 20 percent increase in food prices could lead to an 8 percentage point increase in poverty.

Increased food prices create several problems for the poor, especially in their budget allocations for nonfood items such as health and schooling. According to the United Nations Inter Agency Assessment Mission (2008), the poorest households in Pakistan now need to spend 70 percent or more of their income on food, thus severely compromising their ability to meet essential expenditures on health and education. In turn, there are likely to be more dropouts from school, implying that the country will have a lower chance of achieving its Millennium Development Goal target of 100 percent primary school completion. Similarly, the malnourishment target will also become more difficult to achieve.

Food inflation was very low during 2000–2004, but entered double digits after 2004/05 (see Table 1). The severity of the problem rose when food inflation rose to 23.7 percent in 2008/09—the highest in 23 years. The increase in food prices in Pakistan is generally associated with problems such as the decline in wheat production, increase in international food prices, political economy, and mismanagement by authorities.

Our objective in this article is to identify the determinants of food prices in Pakistan, using (i) the autoregressive distributed lag (ARDL) approach to cointegration, and (ii) different determinants from other studies—Abdullah and Kalim (2011), for example, use the Johansen approach to cointegration and favor the structuralist view that money supply does not have an impact on food inflation, nor do they include world food prices or structural and cyclical variables in their analysis.

The article is organized as follows. Section 2 reviews the determinants of food prices in the context of the subject literature. Section 3 presents our methodology, and Section 4 describes the data and variables used. Section 5 provides an analytical framework, followed by Section 6, which interprets our empirical findings. Section 7 conducts a stability test on the residuals' variance, and Section 8 concludes the study.

Table 1: Food Inflation in Pakistan

Year	Food inflation	Year	Food inflation
1971/72	3.39	1991/92	9.94
1972/73	10.59	1992/93	11.89
1973/74	34.79	1993/94	11.34
1974/75	27.80	1994/95	16.49
1975/76	10.98	1995/96	10.13
1976/77	12.15	1996/97	11.90
1977/78	7.82	1997/98	7.65
1978/79	6.09	1998/99	6.46
1979/80	8.50	1999/2000	1.68
1980/81	13.08	2000/01	3.56
1981/82	13.56	2001/02	2.50
1982/83	2.75	2002/03	2.83
1983/84	7.90	2003/04	6.02
1984/85	5.91	2004/05	12.48
1985/86	2.58	2005/06	6.92
1986/87	3.97	2006/07	10.28
1987/88	8.02	2007/08	17.64
1988/89	14.15	2008/09	23.70
1989/90	4.47	2009/10	12.47
1990/91	12.91	2010/11	17.35

Note: We have calculated the food CPI, followed by food inflation, using the following formula: $Food\ Inflation = \frac{Food\ CPI_t - Food\ CPI_{t-1}}{Food\ CPI_{t-1}} X\ 100$

Source: Government of Pakistan. *Pakistan economic survey* for 1971/72 to 2010/11.

2. Determinants of Food Prices: A Literature Review

Several studies have examined the determinants of food prices, especially after the latter's recent increase. The first major food price hike occurred in 1973. In this context, Eckstein and Heien (1978) identify a number of factors that accounted for food inflation in the US in 1973, including monetary policy, actions by both the US and foreign governments, the Soviet grain deal, world economic conditions, devaluation of the US dollar, and rapid income growth as the American economy moved out of a recession. Lamm and Westcott (1981) find that increased factor prices affect food prices and, moreover, that increased farm-level prices and substantial rises in nonfarm resource prices appear to explain why food prices were affected more than nonfood prices in the 1970s.

Lapp's (1990) results show that variations in the growth rate of money supply—either anticipated or unanticipated—did not affect the average price level received by farmers relative to other prices in the economy during 1951–85. The positive impact of unexpected money growth on the relative prices of agricultural commodities is significant only for a short period. His findings show that the estimated effect is quantitatively small and that, economically, there is no significant variation in the relative prices of agricultural commodities.

Khan and Qasim (1996) conclude that food inflation is driven by money supply, value-added in manufacturing, the wheat support price, and the price of utilities. Nonfood inflation is determined by money supply, real gross domestic product (GDP), import prices, and electricity prices. It is not surprising that changes in the wheat support price should affect the food price index, given that wheat products account for 14 percent of the index. Using ordinary least squares, Khan and Gill (2007) analyze the impact of money on both food and general price indices for the period 1975–2007. They emphasize the comparison between the food CPI and overall CPI, and find that M1 is more strongly associated with the overall CPI than with the food CPI.

The Asian Development Bank (ADB)'s (2008) study addresses three sets of factors that are underscored as the main causes of high food prices in developing Asia. The first is the distinction between supply and demand, the second is the distinction between structural and cyclical factors, and the third is the relationship between international and domestic markets. The structural factors identified are the fall in production growth below consumption growth over several years. Rice and wheat stocks have ebbed and are now about 200 million metric tons, compared with 350 million metric tons in 2000—a decline of about 43 percent (United States Department of Agriculture, 2008).

One of the most important demand factors that influence food prices is the change in dietary habits of people in emerging market economies due to an increase in their income (ADB, 2008). People with higher incomes have now shifted to meat and dairy products, which requires that large amounts of grain be fed to livestock and causes a decline in grain production for human consumption. The other major policy-related factor that has affected food prices is the competing use of food grain to produce ethanol as a substitute for oil. Bio-fuel demand has also risen and led to the diversion of grains, soybeans, sugar, and vegetable oil from use as food or feed (ADB, 2008).

Capehart and Richardson (2008) argue that higher commodity and energy costs are key determinants of higher food prices in the US. Similar to the ADB's (2008) study, they address issues of rapidly changing consumption patterns, i.e., greater demand for processed foods and meat in countries such as China and India, which require more food grains and edible oil, leads to reduced stocks of corn, wheat, and soybeans at the world level and increases food prices. The study also identifies some important supply-side determinants, such as urbanization and the competing demand for land for commercial—as opposed to agricultural—purposes. Moreover, the neglect of investment in agricultural technology, infrastructure, and extension programs is also to blame for the lack of rapid growth in the supply of rice (International Rice Research Institute, 2008).

Gómez (2008) finds that the inflation and exchange rates in China and India are significant in explaining food inflation in Colombia. He points out, however, that the recent increase in food inflation in Colombia in 2007 was also due to drought and expansionary monetary policy, but that its effect was only short-term. The change in consumption habits due to the country's rise in per capita income has increased the demand for meat relative to the demand for cereals, and led to food inflation. Increasing agricultural growth would reduce food inflation and benefit poorer countries.

Naim (2008) argues that factors that may account for the recent inflation include rising energy prices, nonfood hedging policies against drought years, speculation in food commodity markets, and the US's corn ethanol policy. Trostle (2008) examines the rising world market prices of food commodities, and points out that some factors reflect slower growth in production and more rapid growth in demand, which increases food prices. Recent factors that have affected food prices include global demand for bio-fuel feed stock and adverse weather conditions in 2006 and 2007. Other factors that have also led to food inflation include the decline in the value of the US dollar, rising energy prices, the increasing agricultural cost of production, growing foreign exchange holdings by major food-importing countries, and recent policies adopted by some exporting and importing countries.

Among recent studies on Pakistan, Mushtaq, Ghafoor, Abedullah, and Ahmad (2011) show that the real money supply, real exchange rate, and openness affect wheat prices in the long run. Abdullah and Kalim (2011), however, argue that money supply does not determine food prices, and that factors such as per capita GDP, food imports and exports, and support prices determine food prices instead.

3. Methodology

In this section, we formulate a framework within which to determine the various factors that may, potentially, affect food inflation in Pakistan. We know that inflation is necessarily a monetary phenomenon in the long run (see Haque & Qayyum, 2006; Kemal, 2006). Khan and Qasim (1996) find that money supply is one of the major causes of food inflation in Pakistan, while Abdullah and Kalim (2011) argue that it is an insignificant factor. Other than money supply, demand and supply factors, cyclical and structural factors, and international and domestic shocks are crucial in explaining increases in food prices.

We start with a simple microeconomic demand-and-supply framework from which to derive an equilibrium price. We then add to this model other cyclical and structural variables and international price variables. Demand-side factors that affect the quantity demanded of food include the price of food, income, and money demand.

$$Q_d^F = \alpha_0 + \alpha_1 FP + \alpha_2 PCI + \alpha_3 MS + u_d \tag{1}$$

FP represents the prices of food items, which affect demand negatively; *PCI* represents per capita income, which is positively associated with food demand; *MS* represents money supply, used as a proxy for money demand with an equality constraint (i.e., *MS* = *MD*), which is positively associated with the demand for food; and u_d is the error term.

Supply-side factors that affect the quantity supplied of food include food prices, subsidies, energy prices, and domestic production.

$$Q_s^F = \beta_0 + \beta_1 FP + \beta_2 SUB + \beta_3 Y + \beta_4 Energy\,\mathrm{Pr}ices + u_s \tag{2}$$

We expect to find a positive association between quantity supplied and food prices (*FP*). *SUB* represents subsidies to the agricultural sector, which is positively associated with quantity supplied; *Y* is the output of food items per year in the country, which is positively associated with quantity of food supplied. Energy prices affect supply in two ways: (i) through a decline in production, which is covered in the domestic production variable, and (ii) through transportation costs. Finally, u_s is the error term.

In this framework, the prices of food items are determined at equilibrium when the quantity of food items demanded is equal to the quantity supplied:

$$Q_d^F = Q_s^F \quad \Rightarrow$$
$$\alpha_0 + \alpha_1 FP + \alpha_2 PCI + \alpha_3 MS + u_d = \beta_0 + \beta_1 FP + \beta_2 SUB + \beta_3 BI + \beta_4 Y + \beta_5 Energy\,\mathrm{Pr}ices + u_s$$

After rearranging, this yields

$$FP = \gamma_0 + \gamma_1 PCI + \gamma_2 MS + \gamma_4 SUB + \gamma_4 Y + \gamma_5 BI + \gamma_6 Energy\,\mathrm{Pr}ices + v \quad (3)$$

$$\gamma_0 = \frac{\beta_0 - \alpha_0}{\alpha_1 - \beta_1},\ \gamma_1 = \frac{-\alpha_2}{\alpha_1 - \beta_1},\ \gamma_2 = \frac{-\alpha_3}{\alpha_1 - \beta_1},\ \gamma_3 = \frac{\beta_2}{\alpha_1 - \beta_1},\ \gamma_4 = \frac{\beta_3}{\alpha_1 - \beta_1},$$
$$\gamma_5 = \frac{\beta_4}{\alpha_1 - \beta_1},\ \gamma_6 = \frac{\beta_5}{\alpha_1 - \beta_1},\ v = \frac{u_s - u_d}{\alpha_1 - \beta_1}$$

Equation (3) derives equilibrium food prices from the demand and supply framework. Y, agricultural output, is treated as a structural and cyclical determinant of food prices. It indicates the impact of current production on food prices, which, over time, increases or declines. What remain missing, however, are international food prices. These are incorporated in Equation (4), which gives all the variables in natural log form.

$$\log(FP) = \gamma_0 + \gamma_1 \log(PCI) + \gamma_2 \log(MS) + \gamma_4 \log(SUB) + \gamma_5 \log(Y) +$$
$$\gamma_6 \log(BI) + \gamma_7 \log(Energy\,\mathrm{Pr}ices) + \gamma_8 \log(WFP) + v \quad (4)$$

4. Data and Variables

4.1. Sources of Data

Data on the food CPI, per capita income, population, and money supply has been drawn from the Government of Pakistan's (n.d.) *Pakistan economic survey*. Data on agricultural subsidies is from the Government of Pakistan's (n.d.) *Federal budget: Budget in brief*, while that on food crop production is from the *Agricultural statistics of Pakistan* (Government of Pakistan, n.d.). Data on bureaucratic efficiency has been taken from the

Political Risk Services Group (n.d.), and data on world food prices from the International Monetary Fund Statistics Department (2008). The annual data for all variables is for the period 1970–2010, apart from world food prices, which is available up to 2008. All the variables used are in natural log form, which gives direct elasticities.

4.2. Description of Variables

This section looks at the expected signs of the variables shown in Equation (4).

4.2.1. Per Capita Income (PCI)

We include *PCI* as a demand-side determinant of food inflation, using it as a proxy for the country's dietary habits. A higher *PCI* leads to higher consumption of food as well as a change in dietary habits, e.g., the increased consumption of meat and dairy products over that of cereals. This requires a large amount of grain feed for livestock and, so, causes a decline in the production of grain for human consumption. Hence, the food price of grain for human consumption increases since it is now more valuable. Thus, we expect to find per capita income to be positively associated with food prices.

4.2.2. Money Supply (MS)

Money supply is a proxy for money demand through the equality constraint $MS = MD$ because people demand more money to spend on consumption. Thus, when more money is demanded for consumption on food, then food prices go up. The higher the money demand, the higher will be the money supply, and the higher the food prices. Thus, money supply is positively associated with food prices.

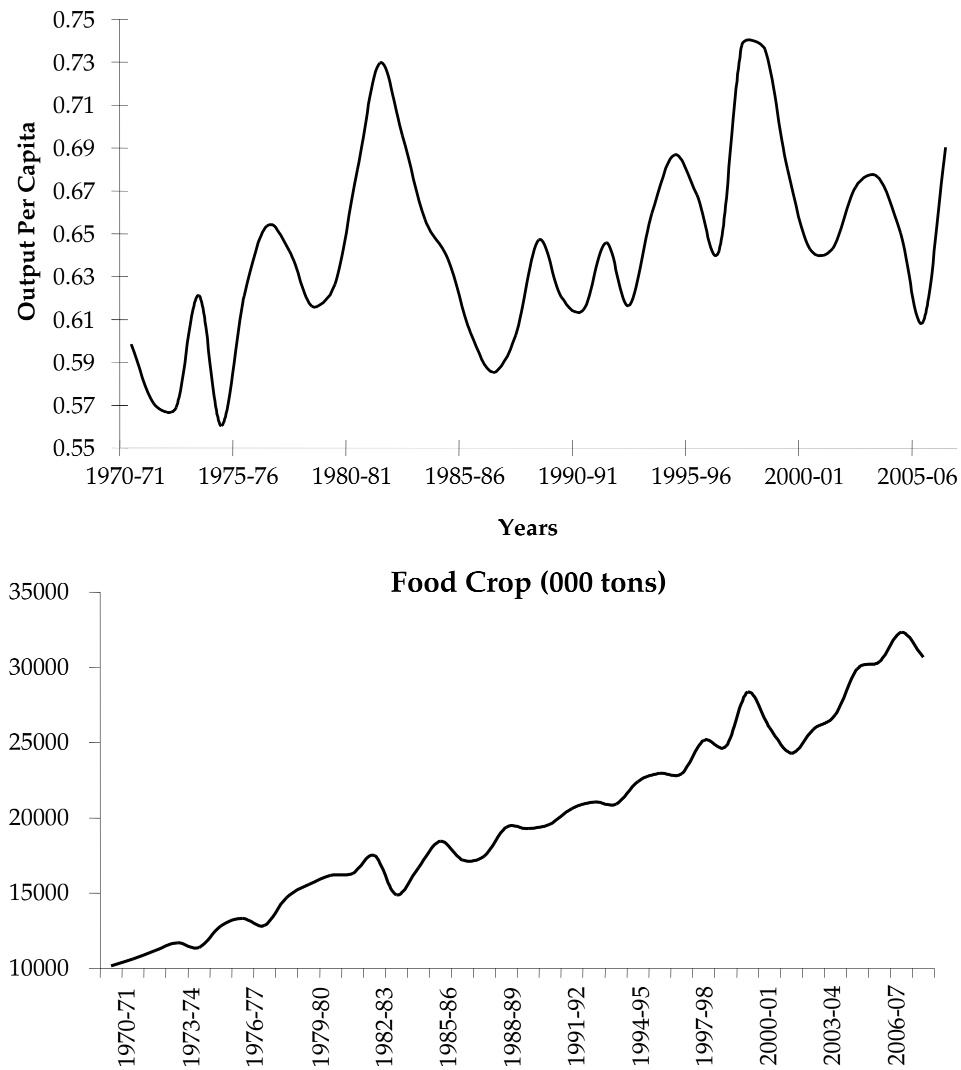
4.2.3. Agricultural Subsidy (SUB)

An agricultural subsidy is a supply-side determinant that can affect food prices in two different ways: (i) it can reduce the cost of production and, hence, decrease food prices; or (ii) it can provide a support price for wheat and other crops to stabilize their prices, giving farmers confidence that they will get at least that amount even if the market price goes down. The subsidy causes suppliers to increase their production, and creates a larger supply in the market, reducing the market price. In both cases, the agricultural subsidy is negatively associated with food prices.

4.2.4. Agricultural Output (Y)

Food crops are taken as an agricultural output, which is a structural and cyclical variable in the long run, representing the output of food items. This variable represents, over time, changes in the production and cyclical movement of food items. The upper part of Figure 1 shows the very irregular movement of agricultural output per capita, while the lower part shows food crop amounts measured in thousands of tons.

Figure 1: Agricultural Output per Capita and Food Crops



Source: Government of Pakistan. *Agricultural statistics of Pakistan* for 1970/71 to 2006/07.

The lower availability of food crops has two outcomes: (i) excess demand, and (ii) it makes things more valuable. In both cases, the prices of food crops go up. Thus, we expect to find a negative association between food crops and food prices.

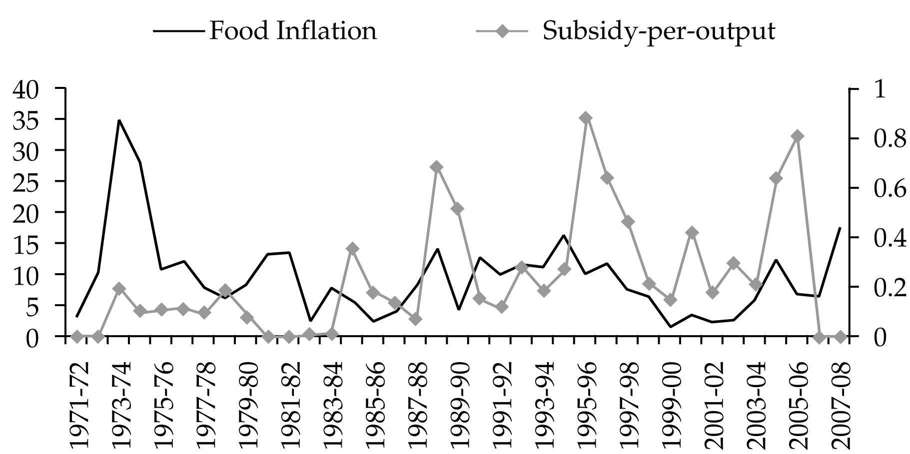
4.2.5. World Food Prices (WFP)

World food prices are the third type of determinant of food prices discussed by the ADB (2008). They show the interlinkage between domestic and international markets. An increase in international prices can impact domestic prices (i) by putting pressure on the domestic market, because exporters may legally or illegally export those commodities; or (ii) through the import of food crops if there is a deficiency of those products in the country. In both cases, world food prices are positively associated with domestic food prices.

4.3. Descriptive Analysis of Data

Figure 2 shows the subsidy–output ratio and annual food inflation. Overall, the movement in the two variables is ambiguous but there are periods of positive and negative association. However, in the late 1990s, the decline in subsidies is matched by a decline in prices, which is surprising. A 33 percent correlation between the two variables is too low to explain any association between the variables.

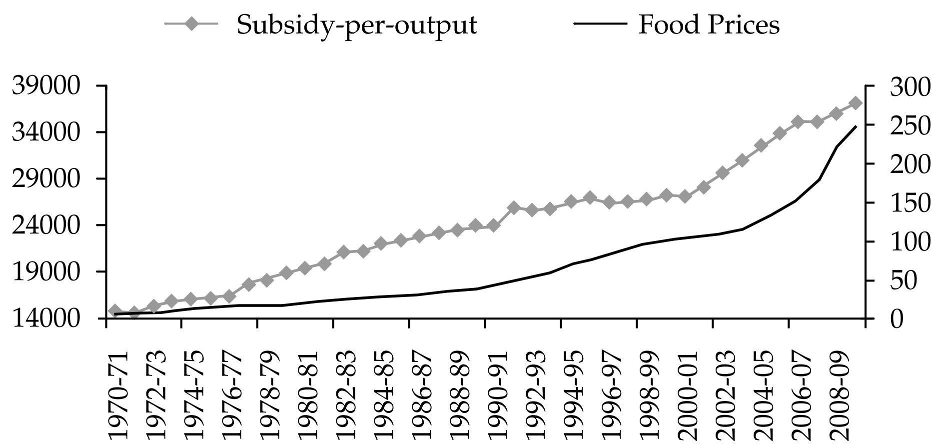
Figure 2: Subsidy–Output Ratio and Annual Food Inflation

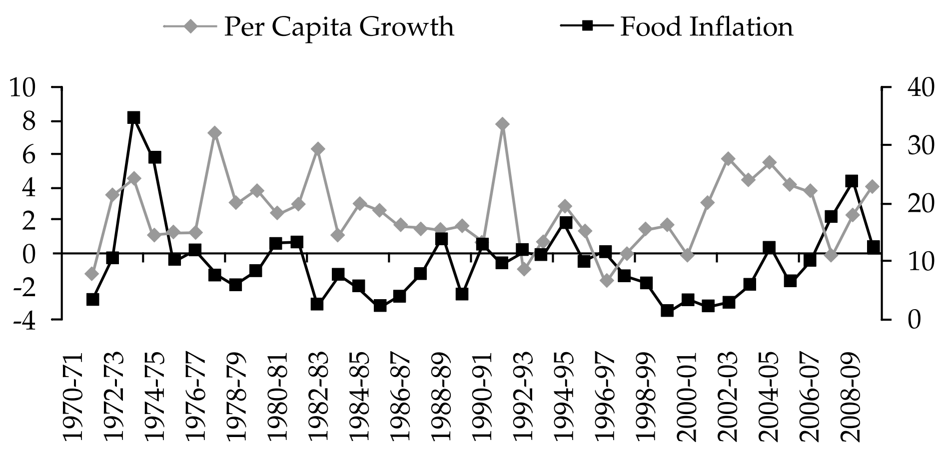


Source: Authors' estimates based on data from Government of Pakistan, *Federal budget: Budget in brief* and *Pakistan economic survey* for 1971/72 to 2007/08.

Figure 3 shows a significant, positive, long-run association between per capita income and food prices. However, if we look carefully at the graph, we can see a negative association in certain periods. Apart from in 1995 and 2003, food prices grow at an increasing rate while per capita income rises at a decreasing rate up until early 2000, after which it increases at a constant rate. Correlation between the two variables is very high at 93.35 percent, which shows that their relationship is significant. Interestingly, however, correlation between food inflation and per capita income growth is –4 percent, which is both very low and negative.

Figure 3: Per Capita Income and Growth Relative to Food Prices and Inflation

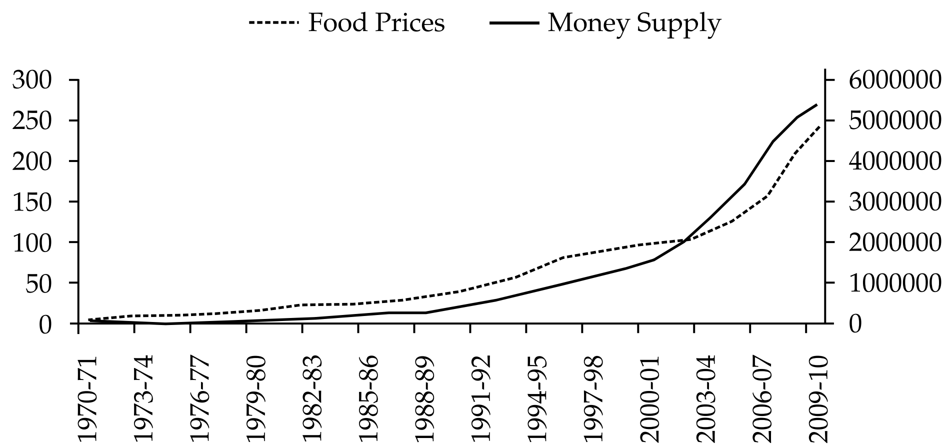


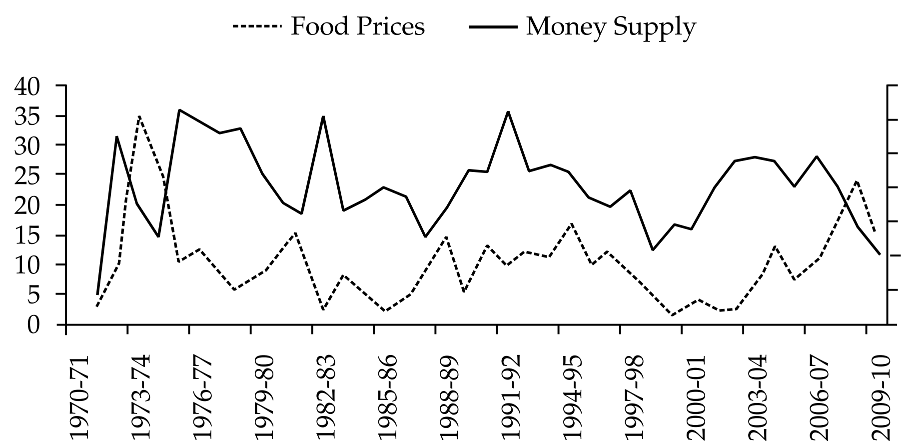


Source: Authors' estimates based on data from Government of Pakistan, *Pakistan economic survey* for 1970/71 to 2008/09.

Figure 4 shows that there is a strong, positive relationship between money supply and food prices in the long run. However, the bottom figure indicates that money growth has a lagged impact on food inflation in the short run. Correlation between the two variables is considerably high at 97 percent. Correlation between money growth and food inflation with a one-period lag is 23 percent, which is positive but not very high.

Figure 4: Food Prices and Inflation Relative to Money Supply and Growth

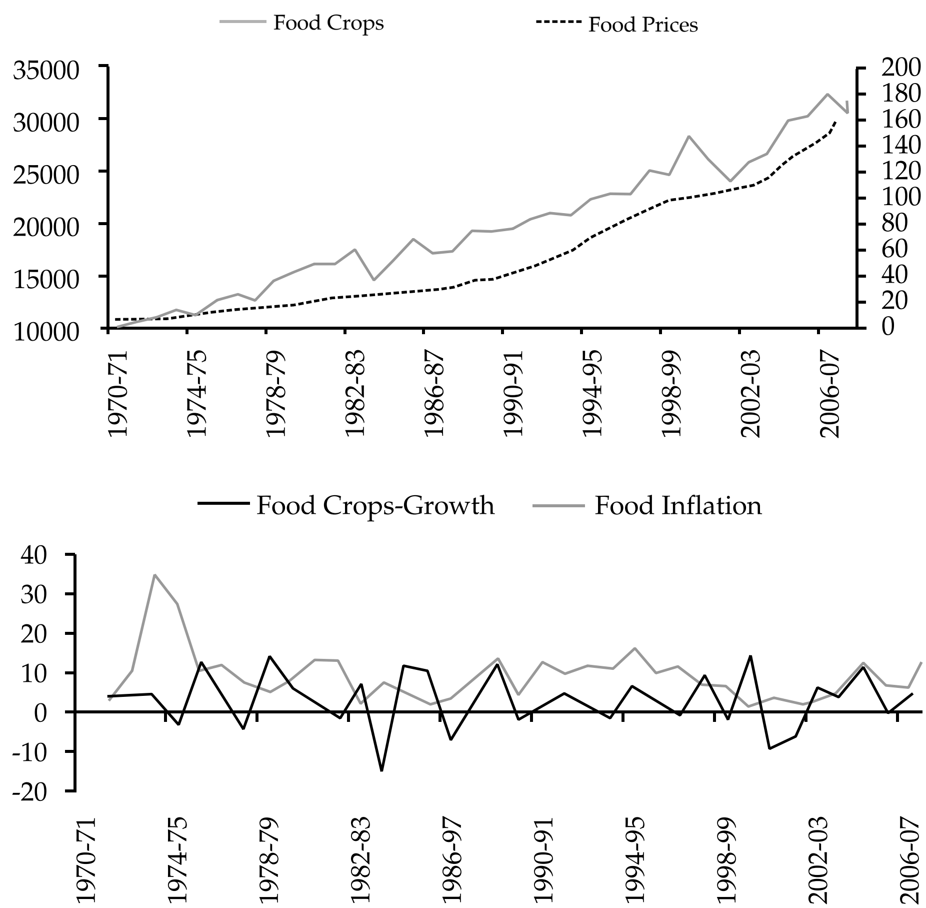




Source: Authors' estimates based on data from Government of Pakistan, *Pakistan economic survey* for 1970/71 to 2009/10.

Figure 5 shows food crop movements relative to food prices, and growth in food crop movements relative to food inflation. Food crops show fairly irregular movements while food prices do not respond to this movement as such. The bottom figure depicts random walk behavior by food crop growth, which is not matched by the movements in food inflation.

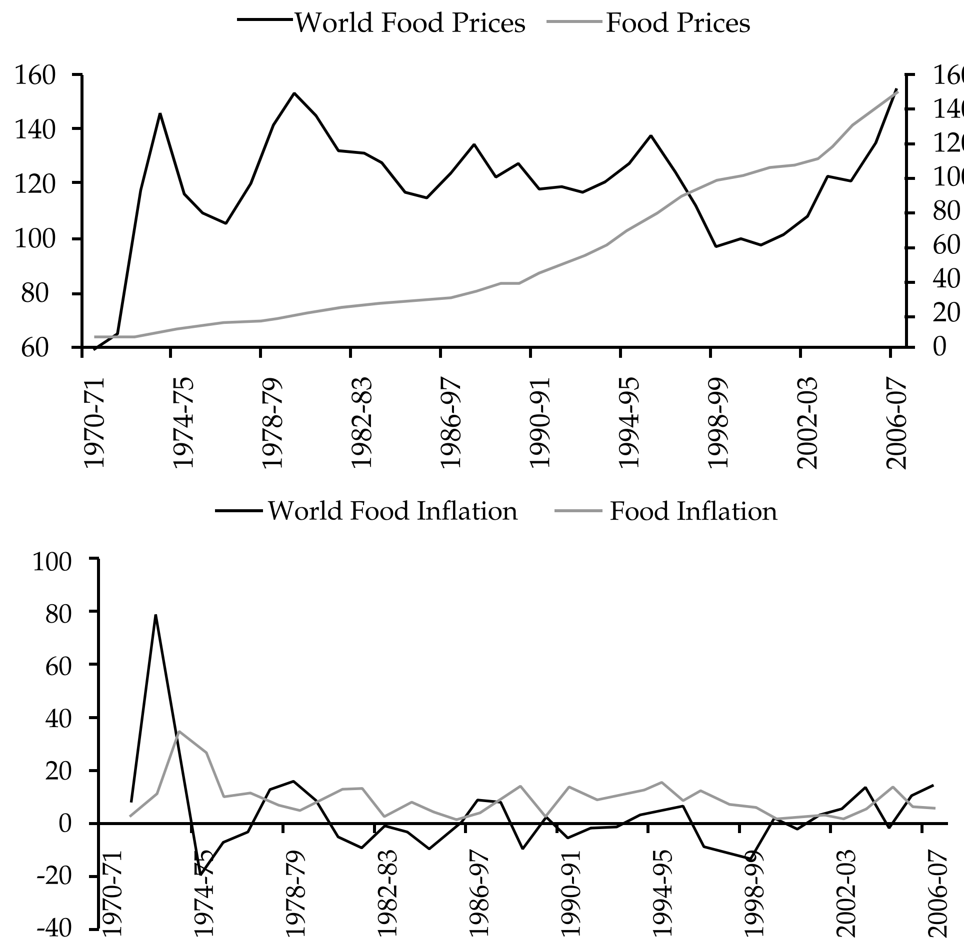
Figure 5: Food Crop Movement and Growth Relative to Food Prices and Inflation



Source: Authors' estimates based on data from Government of Pakistan, *Agricultural statistics of Pakistan* and *Pakistan economic survey* for 1970/71 to 2008/09.

Figure 6 presents an ambiguous relationship between domestic food prices and world food prices, although the series has followed the same trend and has had a significant association over time since 1998/99. The figure shows that domestic inflation responds to world food inflation with a period lag—the correlation between the two variables with a one-period lag is 74 percent. This implies that the two variables are clearly associated with one another.

Figure 6: Movement of Domestic and World Food Prices and Inflation



Source: Authors' estimates based on data from International Monetary Fund Statistics Department and Government of Pakistan, *Pakistan economic survey* for 1970/71 to 2006/07.

5. Analytical Framework

Since we are interested in examining the determinants of food prices in both the long- and short run, we will use a cointegration analysis. There are several techniques available for this, including the Johansen approach, Engle–Granger approach, and ARDL approach, but each starts in almost the same way: If the variables are integrated of the same order and their linear combination is integrated of an order less than the order of the variables, it implies that there is cointegration among the variables. However, more recent approaches, such as that of the ARDL model, also allow variables of different orders of integration.

5.1. Unit Root Test

We apply the augmented Dickey–Fuller (ADF) test—using both a constant and trend, and lagged differences of the logs of all the variables—to check the unit root of the series. If the series has a unit root, i.e., if it is not stationary in levels, this implies that the series is nonstationary. We then check the series in first differences using both the constant and trend and appropriated lagged differences. If the series remains nonstationary, we take the second difference of the variable; this process continues until we obtain the desired results. However, if it is stationary in first differences, we stop there. Lagged differences are an essential part of the ADF test, which help avoid the problem of serial correlation. The optimal lag levels are chosen using the minimum Akaike information criterion (AIC). The specifications for the ADF tests are

$$\log(\mathrm{y}_t) = \rho \log(y_{t-i}) + \gamma \sum_{i=1}^{n} \Delta \log(y_{t-i}) \tag{5}$$

$$\log(\mathrm{y}_t) = \alpha + \rho \log(y_{t-i}) + \gamma \sum_{i=1}^{n} \Delta \log(y_{t-i}) \tag{6}$$

$$\log(\mathrm{y}_t) = \alpha + \beta t + \rho \log(y_{t-i}) + \gamma \sum_{i=1}^{n} \Delta \log(y_{t-i}) \tag{7}$$

$$\Delta\log(\mathrm{y}_t) = \delta \log(y_{t-i}) + \gamma \sum_{i=1}^{n} \Delta \log(y_{t-i}) \tag{8}$$

where y is any variable, t is the trend variable, ρ is the autocorrelation coefficient, α and β are parameters, ε is the error term, and subscript t represents time periods. However, we run the ADF test in difference form, and thus Equations (5), (6), and (7) become

$$\Delta\log(\mathrm{y}_t) = \alpha + \delta \log(y_{t-i}) + \gamma \sum_{i=1}^{n} \Delta \log(y_{t-i}) \tag{9}$$

$$\Delta\log(\mathrm{y}_t) = \alpha + \beta t + \delta \log(y_{t-i}) + \gamma \sum_{i=1}^{n} \Delta \log(y_{t-i}) \tag{10}$$

Thus, the stationarity test is applied to three autoregressive processes: (i) of order one with no intercept or trend, (ii) with an intercept but no trend, and (iii) with both an intercept and trend. We check the lagged differences using the minimum AIC or Schwarz's Bayesian criterion (SBC).[2] Our one-tailed null hypothesis is

$$H_o = \rho \geq 1 \quad or \quad \delta \geq 0$$
$$H_A = \rho < 1 \quad or \quad \delta < 0$$

If H_o is rejected, the series has no unit root and is, therefore, stationary. If H_o is not rejected, we conclude that there is a unit root in the series and that it is nonstationary. The test is initially applied in levels; if the level is nonstationary, the test is then applied in first differences. If the first difference is also nonstationary, the test is applied in second differences, and so on.

Other approaches to checking for unit roots in the data include the Phillips–Perron (PP) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (1992) test. The PP test determines stationarity in the presence of structural breaks in the data. Its null hypothesis is the same as that of the ADF test, i.e., that there is a unit root in the series. Unlike the ADF and PP test, however, the KPSS test's null hypothesis is that there is no unit root in the series. Thus, if the null hypothesis is accepted, then the series is considered stationary. We apply all three tests to our data to avoid any bias.

5.2. Cointegration

Of the various approaches to cointegration, the most popular are the Engle–Granger single-equation, two-step, approach; the multiple-equation Johansen approach; and the ARDL single-equation approach. Since our objective is to determine the long-run determinants of food prices, we do not use the Johansen approach, which is better suited to multiple cointegrating vectors.[3] The Engle–Granger approach has certain shortcomings, which are mostly overcome by Pesaran and Shin's (1997) ARDL approach (see also M. A. Khan, Qayyum, & Sheikh, 2005). The ARDL approach yields consistent estimates of the long-run coefficients irrespective of the order of integration of the variables, i.e., whether they are integrated of order one, I(1) or zero, I(0) (Pesaran & Shin, 1997).

[2] The AIC is preferable to other approaches to lag selection, especially when the sample size is smaller than 60 (Liew, 2004).
[3] It is not necessary to check for multiple cointegrating vectors, since this is not our objective.

We estimate the long-run equation as follows, and use the F-statistic to check the significance of the variables in lagged level form jointly, i.e., where H_o is $\beta_1 = \beta_2 = 0$. If the F-statistic is significant, we can assume that there is a long-run relationship between the variables.

ARDL Representation (Two-Variables Case)

$$\Delta y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 x_{t-1} + \sum_{i=1}^{n} \beta_3 \Delta y_{t-i} + \sum_{i=1}^{n} \beta_4 \Delta x_{t-i} + \varepsilon_t \tag{11}$$

The number of lagged differences is determined using either the AIC or SBC. This can be checked using a general-to-specific (GTS) methodology, i.e., by checking the significance of all the differenced variables jointly at each lag. For example, if we regress the equation including four lags (lagged differences) for each variable, check all the terms of lag four jointly using the F-statistic, and find that it is insignificant, then we would have to regress the equation once again using three lags, and continue this process until it yielded statistically significant results. After the final estimation, we check the joint significance of the lagged variables. In this equation, it is $\beta_1 = \beta_2 = 0$. If it is significantly different from 0, then this implies that there is a long-run relationship among the variables.

Checking the unit root of the residuals is one of the major steps of cointegration. Residuals should be integrated of order zero. To obtain the residuals, we use the equation $\hat{\varepsilon}_t = \beta_1 y_{t-1} + \beta_2 x_{t-1}$ and then apply the ADF, PP, and KPSS test, to check their stationarity. Following this, we move on to the error correction equation, which indicates the adjustment behavior of the dependent variable if it should deviate from the equilibrium path.

6. Empirical Results

Table 2 presents the results of the three unit root tests. In addition to the ADF test, we have applied the PP test, which is used when there are structural breaks in the series—a very common occurrence in economic policy variables such as subsidies if they are not consistent every year. The KPSS test has a null hypothesis that is opposite to the ADF and PP tests, and states that the series is stationary. This is a Lagrange multiplier test, which assumes that the random walk has a zero variance.

The results of the stationarity tests show that food prices, money supply, per capita income, and food crops are nonstationary variables but are integrated of order one, i.e., they are stationary in first differences. However, subsidies and world food prices are level stationary. Apart from the subsidy variable, all three tests yield the same results. Since both the ADF and PP tests give the same results for the subsidy variable—i.e., indicate that it is stationary—we also conclude that it is stationary.

Table 2: Results of Stationarity

	ADF					
Variable	**Constant + trend**		**Constant**		**KPSS**	**PP**
Ln (food prices)	–4.27*	(10)	–0.43	(11)	–0.78*	–0.88
Δ Ln (food prices)	–4.22*	(10)	–4.51*	(10)	0.13	–3.58**
Ln (money supply)	–2.26	(2)	–2.75	(12)	0.78*	–0.85
Δ Ln (money supply)	–4.13**	(7)	–3.29**	(4)	0.11	–5.31*
Ln (PCI)	–1.90	(1)	–0.69	(1)	0.77*	–0.16
Δ Ln (PCI)	–3.98**	(1)	–4.01**	(1)	0.10	–5.87
Ln (food crops)	–3.51	(1)	–1.14	(8)	0.73*	–0.87
Δ Ln (food crops)	–6.73*	(1)	–6.81*	(1)	0.05	–9.39*
Ln (subsidy)	–4.75*	(1)	–4.01*	(1)	0.79*	–8.24*
Ln (world food prices)	–6.40*	(1)	–6.43*	(1)	0.18	–4.08*

Note: Asterisks * and ** indicate significance at 1 and 5 percent, respectively. Lagged differences are given in parentheses.
Source: Authors' estimates.

Equation (4) was given in log linear form. We have used all the variables and can now estimate Equation (12), which represents the ARDL approach to cointegration.

$$\Delta fp_t = \beta_0 + \beta_1 fp_{t-1} + \beta_2 SUB_{t-1} + \beta_3 PCI_{t-1} + \beta_4 Y_{t-1} + \beta_5 ms_{t-1} + \beta_6 wfp_{t-1} + \sum_{i=1}^{n}\beta_7 \Delta fp_{t-i} + \sum_{i=1}^{n}\beta_8 \Delta SUB_{t-i} + \sum_{i=1}^{n}\beta_9 \Delta PCI_{t-i} + \sum_{i=1}^{n}\beta_{10} \Delta Y_{t-i} + \sum_{i=1}^{n}\beta_{11} \Delta ms_{t-i} + \sum_{i=1}^{n}\beta_{12} \Delta wfp_{t-i} + \varepsilon_t \quad (12)$$

Equation (12) represents the ARDL model of the estimated equation. All the variables are in log form: *FP* is the log of food prices, *SUB* is the subsidy in log form, *PCI* is the log of real per capita income, FC is the log of food crops, MS is the log of money supply, WFP is the log of world food prices, and ε_{1t} is the error term of Equation (9). Subscript *t* represents the time period, the β terms are the coefficients of each variable, and n represents the number of lags.

The minimum AIC indicate the number of lagged differences as being three. After estimating the entire equation with all the variables at three lag levels, we find that there are several insignificant variables affecting the significance of other variables as well. The model allows us to estimate the general model first, and the specific model second, and so is known as a GTS model. The results of the specific ARDL model are given in Table 3.[4] The diagnostic tests for the ARDL model indicate that neither serial correlation (Lagrange multiplier test) nor heteroscedasticity (Breusch–Pagan–Godfrey) are problems.

Table 3: Results of ARDL Equation

Variable	Coefficient	t-statistic	Prob.
D(SUB(–1))	0.015	2.13**	0.0478
D(PCI(–2))	–0.934	–3.22*	0.0050
D(FP(–3))	0.602	5.45*	0.0000
D(SUB(–3))	–0.008	–2.67**	0.0162
FP(–1)	–0.514	–3.65*	0.0020
MS(–1)	0.378	4.24*	0.0006
SUB(–1)	–0.024	–2.38**	0.0293
FC(–1)	–0.104	–1.15	0.2641
WFP(–1)	0.273	5.46*	0.0000
PCI(–1)	–0.295	–2.20**	0.0416

$R^2 = 0.83, \quad \overline{R}^2 = 0.75,$

$\sum \varepsilon_t^2 = 0.0062, \quad AIC = -4.80, \quad SBC = -4.32$

Diagnostic tests	Heteroscedasticity: F = 0.94 [0.52] Serial correlation: F = 0.24 [0.79]

Note: Asterisks * and ** indicate significance at 1 and 5 percent, respectively.
Source: Authors' estimates.

The redundant variables test (Table 4) $(\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0)$ rejects the null hypothesis that the variables have no power. Thus, they are

[4] Energy prices were initially part of the equation but were later dropped since they proved statistically insignificant, and the GTS model does not allow insignificant variables to be part of the model. Energy prices are not, therefore, among the determinants of food prices in Pakistan in our model.

significantly different from 0, which implies that there may be a long-run relationship among them.

Table 4: Redundant Variables

Redundant variables: FP(–1), SUB(–1), PCI(–1), TP(–1), M2(–1), LWF(–1)			
F-statistic	22.71938	Probability	0.000000*
Log likelihood ratio	59.38082	Probability	0.000000*

Note: Asterisk * indicates significance at 1 percent.
Source: Authors' estimates.

Table 5 shows normalized cointegrating vectors (long-run coefficients). We normalize the coefficients of lagged-level variables by dividing the coefficient of *FP* (assuming all the other coefficients are equal to 0) and obtaining the long-run elasticities. The results show that the subsidy variable is negatively associated with food prices.[5] However its coefficient is too small to have a significant role in the long run; the implication is that a 100 percent increase in subsidies reduces food prices by 5 percent. Surprisingly, per capita income is negatively associated with food prices. The coefficient shows that a 1 percent increase in per capita income leads to a decline in food prices by 0.57 percent.

Table 5: Normalized Cointegrating Vectors

Variable	Coefficient	t-value
FP(–1)	1.00	
MS(–1)	–0.74	–4.24*
SUB(–1)	0.05	2.38**
FC(–1)	0.20	1.15
WFP(–1)	–0.53	–5.46*
PCI(–1)	0.57	2.20**

Note: Asterisks * and ** indicate significance at 1 and 5 percent, respectively.
Source: Authors' estimates.

Food crop production is used to capture the structural and cyclical impact on food prices. Over time, an increase in food crops increases the total supply of food crops, thus reducing food prices and vice versa. The negative sign of food crop variable shows the overall structural effect of a decrease in production leads to an increase in prices and vice versa.

[5] The equation is: $\varepsilon_t = fp_{t-1} + \beta_2 SUB_{t-1} + \beta_3 PCI_{t-1} + \beta_4 Y_{t-1} + \beta_5 ms_{t-1} + \beta_6 wfp_{t-1}$

However, it is not statistically significant and, therefore, not a significant determinant of food prices in the long run.

Money supply appears to be the most significant variable determining the variation in food prices. Its coefficient is 0.74, which implies that a 1 percent increase in money supply leads to a 0.74 percent increase in food prices. World food prices, the only international variable in our analysis, are positively associated with food prices. Its coefficient implies that a 1 percent increase in world food prices leads to a 0.53 percent increase in domestic food prices in the long run, which is quite high.

Next, we generate the residual of the equation and check its stationarity. If it is integrated of order zero, then it satisfies another condition of the presence of cointegration among the variables. The ADF, PP, and KPSS tests show that the residual is level stationary.[6]

We then proceed to check the error correction in the dependent variable. The error correction model is represented by

$$\Delta fp_t = \beta_0 + \sum_{i=1}^{n} \beta_8 \Delta SUB_{t-i} + \sum_{i=1}^{n} \beta_9 \Delta PCI_{t-i} + \sum_{i=1}^{n} \beta_{10} \Delta Y_{t-i} + \sum_{i=1}^{n} \beta_{11} \Delta ms_{t-i}$$
$$+ \sum_{i=1}^{n} \beta_{12} \Delta wfp_{t-i} + \lambda EC_{t-1} + \varepsilon_{2t}$$

where λ represents the speed of adjustment and EC is the residual term obtained from the ARDL model.

Table 6 gives the results of the error correction model. Here, we use one less lag than in the ARDL approach (see, for example, S. Khan & Khan, 2007), i.e., we use two lag differences. Applying the GTS methodology yields better results.

[6] ADF = –2.07** (significant at 5% significance level), PP = –3.66* (significant at 1% significance level), KPSS = 0.12.

Table 6: Results of Short-Run Dynamics (Error Correction Model)

Coefficient	Coefficient	t-statistic	Prob.
EC(–1)	–0.376110	–10.248400	0.0000*
D(MS(–1))	0.173448	3.293961	0.0033*
D(PCI(–1))	–0.744930	–4.797430	0.0001*
D(FP(–2))	0.509757	9.253716	0.0000*
D(SUB(–2))	–0.006180	–2.750190	0.0117*
D(PCI(–2))	–0.333750	–2.315980	0.0303*
D(FC(–2))	0.065018	1.597895	0.1243

$R^2 = 0.876944$, $\overline{R}^2 = 0.843383$,

$\sum \varepsilon_t^2 = 0.004699$, $AIC = -5.407054$, $SBC = -5.077017$

Note: Asterisk * indicates significance at 1 percent.
Source: Authors' estimates.

The overall result indicates the significant presence of error correction in the equation. Its negative sign implies that, whenever there is disequilibrium, food prices adjust toward equilibrium to restore it as market forces are in operation. The estimated value of EC_{t-1} (0.376) indicates the speed of adjustment toward long-run equilibrium in response to disequilibrium, which is due to short-run shocks of the previous period—a rate of 37.6 percent. Since we have annual data, we assume it takes almost three years to restore complete equilibrium.

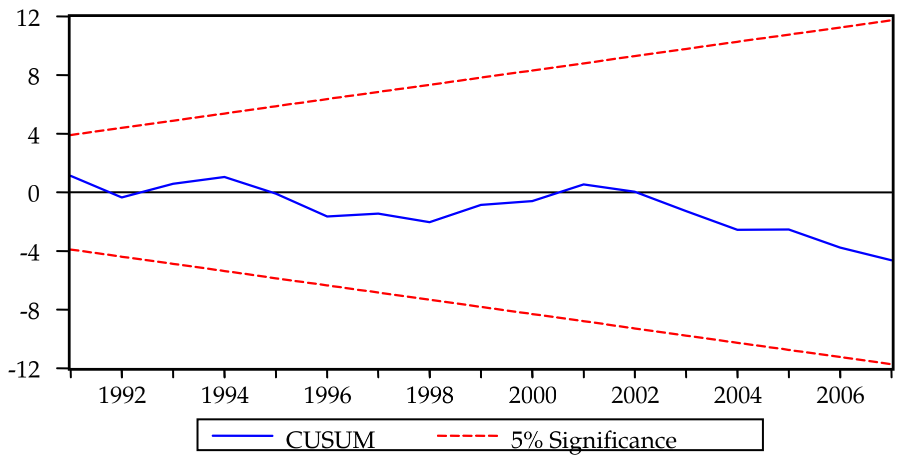
Money supply has a positive sign and is significant, indicating that it plays an important role in raising food prices in the short run. Per capita income has a negative impact on food prices even in the short run. Subsidies are effective and have a negative role in the second period in determining prices, which show that they serve to reduce food prices. Farmers are encouraged to grow more of that crop for which the government has announced a support price. Thus, subsidies create greater supply in the market, which helps reduce food prices.

7. Stability Test

In this section, we perform two tests on the ARDL model: (i) a cumulative sum (CUSUM) test and (ii) a CUSUM-of-squares test. Both will verify the stability of our estimates.

The CUSUM test is based on the cumulative sum of the recursive residuals, and measures parameter instability within a 5 percent range. A value beyond this range indicates that the estimation is not stable. Figure 7 illustrates the results of the CUSUM test, which show that our estimates are stable.

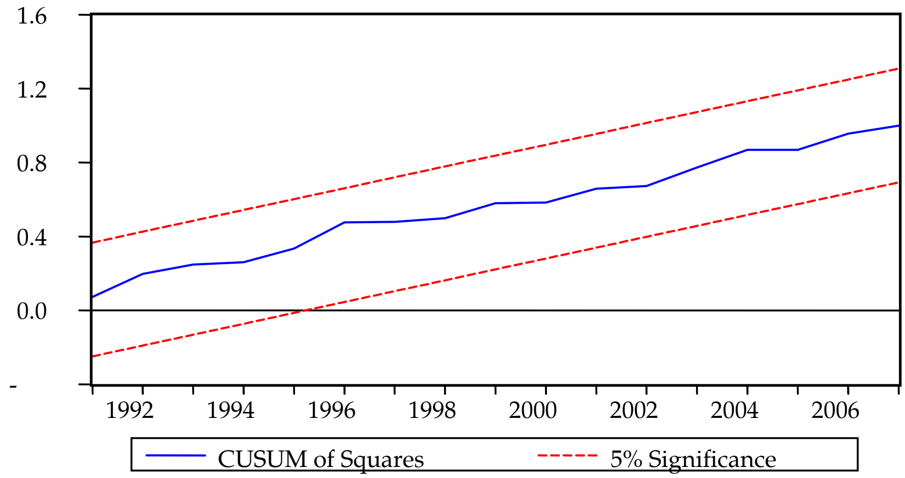
Figure 7: Results of CUSUM Test for Stability of Estimates



Source: Authors' calculations.

The CUSUM-of-squares test is performed on the squares of the residuals. Similar to the CUSUM test, this test measures parameter instability within the given range, and indicates whether or not the variance of the residuals is stable. Figure 8 shows that the cumulative sum of squares is within the given range, implying that our estimates also pass the second stability test.

Figure 8: Results of CUSUM-of-Squares Test for Stability of Estimates



Source: Authors' calculations.

8. Conclusion

Over the last few years, the problem of increasing food prices both in Pakistan and globally has become a severe one. The predicament is not new, and the world has witnessed similar situations since the early 1970s. While there may be different reasons for the recent increase in prices, we have followed a relatively basic economic approach and developed a model including per capita income, agricultural output, agricultural subsidies, money supply, and world food prices as key determinants of food prices in Pakistan.

Our study leads us to conclude that the most significant variable affecting food prices in both the long- and short run is money supply. Agricultural subsidies help reduce food prices in the long run but their impact is very small. In the absence of imports, an increase in world food prices pressurizes the domestic market, causing a rise in domestic food prices. If, however, world food prices increase and we need to import food crops, we may generate imported inflation. The negative association of per capita income and food prices may imply Engle aggregation, i.e., that the percentage of expenditures on food items declines with an increase in income.

This, however, is the study's paradox: Food crop production does not appear to have an immediate effect on food prices, implying that movements in food prices follow factors other than the current production of domestic food crops more significantly. It is possible that the production of food crops follows their price in previous years and certain other factors, and not the other way around—this could be an area for further research. Changes in production over time are also not a major determinant of food prices. While there may be popular debate on energy prices and their impact on inflation, we do not find energy prices to be a key determinant of food prices. An important conclusion of the study is that food prices restore equilibrium when the system is in disequilibrium, but that it can take three years to do so.

We have not touched on the political economy of price increases, e.g., on issues such as smuggling and untimely exports followed by imports at higher prices—these are among the limitations of this study.

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Fatima Ejaz Khan, BBA
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Muniba Shoaib, BBA
Murtaza Najoom Ul Ghaus, BBA
Mustafa Sajid Tirmizi, BBA
Myra Waheed, BBA
Nabeel Ahmed Qureshi, BBA
Nabeel Shaukat Ali Seyal, MBA
Nadeem Ali, BBA
Nadia Shahid, EMBA
Naima Mahmood Khan, BBA
Naima Shamail, BBA
Namra Aslam, BBA
Namra Nadeem, BBA
Namra Shah, BBA
Natasha Farooq, BBA
Natasha Hassan, BSc
Nauman Mahmood, BBA
Naveed Zia, EMBA
Nawal Zubair Rashdi, BSc
Nazish Mohammad, MBA
Neha Kamran, BBA
Nermeen Mehmood, MBA
Nida Jamil, BSc
Nida Khan, MSc
Nida Zafar, BBA
Nimra Ahsan, EMBA
Nimrah Idrees, BSc
Noor Aftab, BBA
Noor -e- Sehar Masood, BSc
Norooz Naveed, BBA
Nosheen Khan, BBA
Nudba Ayatullah, BBA
Omair Farooq, BBA
Omar Farooq Malik, MBA
Omar Khan, BBA
Omar Zaheer Bari, BBA
Omer Khalid, EMBA
Omer Farasat, BSc
Omer Nawaz, MBA
Omer Saeed, BBA
Omer Sarfraz Ali Khan, BBA
Omer Shahzad Siddique, MBA
Osama Ahmed, BBA
Osama Muzammil, BBA
Osama Rizwan, BBA
Osama Zubair, BBA
Osman Khan, BBA
Qasim Hussain Chattha, BBA
Qudsia Sami Khan, BBA
Qurat- Ul-Ain Fahim, EMBA
Quratulain Zulfiqar, MBA
Qureshi Raphay Shahad, BBA
Raafay Munir Haider Gill, MBA
Rabia Samdani, BBA
Rabiya Abdul Wahid, MBA
Rafia Arif, BBA
Rai Bilal Zafar, BBA
Raja Fahad Asghar, BBA
Rana Muhammad Fahad Dastgir, BBA
Rao Muhammad Rizwan, EMBA
Rashid Ahmad, BBA
Rauf Shehryar Afzal, BBA
Reema Aftab, BSc
Rehman Akram Chaudhary, BBA
Rida Shafqat, BBA
Riyan Durrani, BSc
Rizwan Hameed, BBA
Rubab Ali Raza, BBA
Rushdia Amanat, MBA
Saad Farrukh, BBA
Saad Haroon, BSc
Saad Hashmi, BBA
Saad Islam, BSc
Saad Karim Laghari, EMBA
Saad Khan Durrani, BBA
Saad Sajjad Bhatti, BBA
Saad Ullah Jaral, BBA
Saara Usman, BBA
Saba Javaid, MBA
Saba Javed Hayat, BSc
Saba Tahir, BSc
Sabeeh Farooq Khokhar, BBA
Sadaf Ikram, BBA
Sadaf Shahid, BSc
Sadiqa Syed, BBA
Sahar Anjum, BSc
Saher Rashid, BBA
Saher Yousaf, MS
Saima Farheen, EMBA
Saima Naveed, MBA
Saira Bano, MBA
Saira Shehzad, BSc

Sajid Nawaz Ghauri, EMBA
Sakina Suhail Mannan, BBA
Saleh Hasan, BBA
Saleha Baig, BBA
Saleha Noor, BBA
Saliha Bokhari, BBA
Salman Ahmad Tariq, BSc
Salman Irshad, BBA
Salman Khalid, BBA
Salman Rasool Dar, BBA
Salman Zafar, BBA
Saman Amin Rai, EMBA
Samar Shoaib, BSc
Samara Afzal, BSc
Sami Ullah Aslam, EMBA
Samiya Nasir Raja, BBA
Sana Ahsan Elahi, MSc
Sana Bashir, BBA
Sana Imtiaz, BBA
Sana Saleem, BSc
Sana Zaheer, BBA
Saniya Malik Ravid, MBA
Saqib Rasul, EMBA
Sara Mahrukh, BBA
Sara Naqvi, BBA
Sarah Ahmed, MS
Sarah Badar, MS
Sarah Hassan Gardezi, EMBA
Sarah Zubair, BBA
Sardar Yusuf Durrani, BBA
Sarmad Afzal, BBA
Saud Waheed Khan, BBA
Sehr Salman, BBA
Sehrish Iftikhar, BBA
Sehrish Nisar, MBA
Sehrish Saleem, BBA
Shaharyar Babar Chaudhary, BBA
Shaharyar Chaudhary, BBA
Shahbaz Farooq Ahmad Khan, MBA
Shaheer Ahmed Khan, BBA
Shahzaib Afzal, BBA
Shahzaibe Aejazi, MBA
Shahzeb Shahzad Shami, BBA
Shahzore Bhatty, BBA
Shamail Arzu, BBA
Shamshair Ali, BBA
Shandana Shahid Dar, BSc
Shanze Sarfraz Cheema, BBA
Shayan Elahi, BBA
Shayan Shaikh, BBA
Shazeb Mazhar, BBA
Shazib Adnan, BBA
Shazil Nazir Sindhu, BBA
Sheema Atta, BBA
Sheeraz Nabi, BBA
Sheher Bano Imtiaz, BBA
Sheheryar Shahid Shafee, BBA
Sheikh Ahmad Khalid, BSc
Shibra Aslam, BBA
Shoaib Khalid, BSc
Shoaib Pervaiz, BBA
Shua Sadiq, BBA
Sibghat Ali Khan, BBA
Sidra Shahzad, EMBA
Sidra Ali, MBA
Sidra Mansoor, BSc
Sidrah Azhar, MBA
Sidrah Tahir, MBA
Sikandar Khan, BBA
Sikander Ali Khan, BBA
Sobia Sarwar, BBA
Sobia Sohail, MBA
Sohaib Arshad Alavi, BSc
Soubia Hassan, EMBA
Sufiyan Tarique, BBA
Sultan Yousaf, BBA
Sundas Iqbal, BBA
Sunnya Saeed, BSc
Syed Abdul Basit, BBA
Syed Abul Hassan Abbas, BBA
Syed Ahmad Hussain, BSc
Syed Ali Akber Kazmi, EMBA
Syed Ameer Haider Gardezi, BSc
Syed Asfand Kamal, MBA
Syed Atta-ul Hassan, BBA
Syed Hassan Tallal Rizvi, BSc
Syed Kamran Raza, BBA
Syed Mohammad Raza Husain, BBA
Syed Muhammad Baqir Abbas Zaidi, EMBA
Syed Muhammad Miqdad Muslim, BSc

Syed Muneeb Ali Shah, MBA
Syed Usman Raza Gillani, MBA
Syed Yasir Ali, BBA
Syed Zeeshan Haider Rizvi, BBA
Syeda Bintay Zahra, BBA
Syeda Gull Zainab Gardezi, BBA
Syeda Hira Bokhari, BBA
Syeda Madiha Atta, BBA
Syeda Sundus Fatima, BBA
Tabinda Jabeen Talib, BBA
Taimoor Ehtisham Anwar, BBA
Taimur Awan, BSc
Taimur Malik Naseer, BBA
Talal Naseem Janjua, BBA
Talha Haroon, BSc
Talha Munir, BBA
Tamour Pervez, MBA
Tayyab Faruki, BSc
Tazeen Asaad, MBA
Tehniyat Ajmal, BSc
Tehreem Humayun, BBA
Toor-e-jamal Jabbar Jaliawala, BSc
Turab Hameed Bajwa, BBA
Ulya Salman, BSc
Umair Adnan, BBA
Umair Ashraf, BBA
Umair Khalid Kharral, BBA
Umair Mahmood, BSc
Umair Raheel, BBA
Umair Ul Hassan, BBA
Umair Zahid, MBA
Umar Attique, BBA
Umar Azam, BBA
Umar Farooq, BBA
Umar Khan, BBA
Ume Abeeha, BBA
Ume Laila Hussain, BBA
Umer Humayun, MBA
Urooj Zawwar Iqbal, BBA
Usman Aslam, EMBA
Usman Tariq, EMBA
Usman Ameer Khan, EMBA
Usman Asif, BSc
Usman Bajwa, MBA
Usman Gul, BSc
Usman Shakil, BBA
Usman Tahir, MBA
Usman Zahid, BBA
Uzair Asif, BBA
Uzair Munir Peracha, BBA
Valeed Shahid Chaudhry, BBA
Vicky Zhuang Yi- Yin, BBA
Wajid Ali, BBA
Waleed Ahmed Tariq, BBA
Waleed Rabbani, BSc
Walia Ahmad, BBA
Waqar Karim Bhutta, BBA
Waqar Nadeem, BBA
Waqas Ali Babar, BBA
Waqas Ghaffar, MBA
Waqas Suleman, BBA
Wasif Munir, BBA
Weeda Sajjad, BSc
Yusra Shakeel, BBA
Zaeem Shahzad Khan, BSc
Zafar Ul-sani Cheema, BBA
Zahid Latif Waince, BBA
Zahra Hamdani, BSc
Zahra Sodhi, MBA
Zahrah Idrees, BBA
Zaid Arif, BBA
Zaid Hameed, MBA
Zain Aijaz, EMBA
Zain Ali Syed, BBA
Zain Mahmood Butt, BBA
Zain Malik, BBA
Zainab Amjad Qazi, BSc
Zainab Javed, BBA
Zainab Razzaq, BSc
Zaineb Khan, BSc
Zara Haroon, BBA
Zara Hussain, MBA
Zara Murtaza, BBA
Zara Saeed Khan, BBA
Zara Tariq, BBA
Zarlasht Gull Khan, BSc
Zeb Rashid Sheikh, BBA
Zeeshan Zafar, BBA
Zoaa Faiq, MBA
Zohaib Ahmad, BBA
Zohaib Ali Jamal, MBA
Zohaib Hussain, BBA

Zohair Javed, BBA
Zohair Juzer Badri, BBA
Zoya Fazeel, BBA
Zubair Akbar, MBA
Zubair Saleem, BSc
Zunaira Mobashir Alam, BSc
Zunoor Zahid, BBA