# CHAPTER 3

# TRADE AND TOTAL FACTOR PRODUCTIVTY IN MANUFACTURING

## 3.1 INTRODUCTION

While some literature on trade policy and market structure provides several mechanisms through which trade expansion may boost industry productivity[37], a significant amount of theoretical literature still delivers disparate predictions regarding the impact of trade on productivity (Pavcnick, 2002:2). Hence, empirical evidence is still vital to inform the debate. In this chapter, therefore, a fundamental issue regarding the mechanisms through which increased trade affects industrial productivity is addressed using the South African panel data set to provide a comprehensive picture of the macroeconomic and structural determinants of manufacturing productivity. This data set combines the advantages of macroeconomic time series and microeconomic cross-sections. South Africa provides a good environment in which to investigate these issues, because trade policy over the last 25 years has exhibited significant variation; there has also been explicit heterogeneity across industrial sectors in response to trade expansion (Fedderke, 2001 Fedderke and Vaze, 2001, TIPS, 2001, Roberts, 2000, Gunnar and Subramanian, 2000).

To obtain a measure of total factor productivity in manufacturing, a production function is estimated in which industry productivity is modelled as an

[37] The first route is via imports; as imports expand, the ensuing competitive pressure results in higher productivity if domestic firms eliminate x-inefficiency or slack and use inputs more efficiently (Fernandez, 2003:3). The second mechanism in which trade may boost plant productivity is by allowing for increased access to imported intermediate inputs of higher quality and broader variety (Iscan, 1997:1). The third channel is that increased trade may influence the incentives to invest in technological innovation (Gunnar and Subramanian, 2000:4).

unobservable industry specific effect. This approach generates sector specific as well as time-varying productivity measures. The investigation searches for the channels through which measures of trade orientation interact with industrial characteristics and the macroeconomic environment to determine productivity. Previous estimates in the literature focussed only on measuring the impact of a single variable on productivity, namely trade policy (Fernandez, 2002:20). A more useful approach is to investigate the channels through which trade affects productivity. Since the analysis is confined to an identical country panel it is possible to consider many variables that might determine productivity, simultaneously.

This chapter provides empirical estimates of the determinants of total factor productivity in South Africa's manufacturing sector. It, therefore, begins with the discussion of the literature relevant to analysis of the productivity and trade linkage in Section 3.2. Section 3.3 looks at issues involved in measuring total factor productivity. The empirical specification is presented in Section 3.4. The data investigated is discussed in Section 3.5. The results, provided in Section 3.6 are followed by concluding comments in Section 3.7.

## 3.2 TRADE AND MANUFACTURING PRODUCTIVITY

If there are benefits to a country's manufacturing sector arising from trade, these benefits should come from two sources. The first source is greater efficiency in production through increased competition and specialisation. The second source is the opportunities that arise to exploit economies of scale in a larger market. Access to a larger market should encourage larger production runs in industries, thus reducing average costs. Trade expansion should, therefore, permit firms to increase in size and engage in more plant specialisation. In an environment of increased trade, consumers demand for variety will be satisfied through imports.

Access to the world market also means that more products can be produced profitably, which should generate gains from increased product diversity and improve consumer welfare (Petersson, 2002:241).

Proponents of trade liberalisation aim to promote productivity gains by exposing industries to fiercer international competition and facilitating access to the international market. They argue that establishments that face foreign competition are forced to adapt. In particular, plants are constrained to produce closer to the production frontier and that the frontier will move out faster. Most importantly, evidence indicates that manufacturing concerns exposed to trade pay higher wages, operate at a higher scale, produce with more capital and achieve higher productivity levels (Van Biesebroeck, 2003). Manufacturing total factor productivity seems to be directly associated with the production of tradable goods, which implies that the benefits from foreign activities are likely to be higher in two areas. First, benefits arise in places where the domestic market is small and foreign sales are a prerequisite to fully exploit scale economies. Second, benefits accrue where production technology lags best practice, providing ample scope for productivity improvements through imitation and adoption of foreign technology. The literature suggests a number of mechanisms or channels through which trade liberalisation affects manufacturing productivity (Fernandez, 2003:3, Van Biesbroek, 2003 Pavcnik, 2000:2, and Muendler, 2002:2). These channels include: the foreign input push, competitive push, competitive elimination, technological innovation and economies of scale. The channels are discussed in sub-sections that follow below.

### 3.2.1 Foreign input push

Easier access to equipment and intermediates may allow a foreign input push at the firm level, because high quality equipment and intermediate goods allow industries to adopt new production methods. The use of these inputs raises efficiency, because the efficiency of foreign equipment and intermediate inputs is higher than the efficiency of domestic inputs (Fernandez, 2003). In the same vein, studies of competitive effects of increased import penetration such as Krishna and Mitra (1998) and Tybout and Westbrook (1995) demonstrate that increased competition from imports, in fact, lowers the price-cost margin.

Increased foreign competition leads to the closure of less productive factories or induces firms to shift their industrial focus (Van Biesbroek, 2003). However, foreign inputs may be only a minor component of the productivity change in some countries. Rather, it is foreign pressure that forces plants to raise productivity, because the shutdown probability of inefficient firms rises with competition from abroad. If productivity is negatively affected by trade protection, gains in productivity should associate positively with increased imports of intermediate inputs and investments in machinery at the plant level (Muendler, 2002:36). Grossman and Helpman (1991) argue that access to higher quality or broader variety of foreign intermediate inputs through trade boosts plant productivity, which explains why firms engaged in export activities benefit from exposure to technology embodied in imported final goods. Such firms obtain, from imported capital goods, previously unavailable technologies to boost productivity. This increase in knowledge, in turn, leads to better technical efficiency. Therefore, differences in firm level efficiency will tend to be greater in industries protected from international competition, due to limited access to foreign technology, expertise or problems acquiring imported intermediate and capital goods, because of protectionism (Muendler, 2002).

### 3.2.2 Competitive push and the elimination of X-inefficiency

Firms are said to respond strongly to increased competitive pressure and raise their efficiency. The turnover and the exit of the less productive firms contribute positively to productivity change. Since the removal of import barriers increases competition on the product market side, foreign imports constitute a competitive push on individual firms. Theory suggests that managers remove agency problems and innovate processes under fierce competition (Pavcnik, 2000:37). In particular, the elimination of X-inefficiency or slack occurs as imports expand. The ensuing competitive pressure results in higher productivity as firms use inputs more efficiently (Fernandez, 2003:3; Fernandez, 2002:4). Trade liberalisation, in essence, induces competitive pressure, which forces firms to raise their efficiency.

By reducing protection, trade liberalisation lowers domestic prices, forcing high cost producers to exit the market. To compete against international producers, domestic firms must adopt newer and more efficient technology or use the same technology with less x-inefficiency in order to reduce costs (Tybout et al, 1991), which could result in a reallocation of output from less efficient to more efficient producers. These gains, however, result only if irreversibility of investment in capital equipment does not stop the exit of less productive plants (Pavcnik, 2000).

### 3.2.3 Competitive elimination

Competition in the product market may also induce more exits and cause a competitive elimination of inefficient producers (Muendler, 2002:28). Increased competitive pressure makes the least efficient firms shut down and enables the surviving, competitive plants to increase market share. The increase in market share is what raises productivity. In Chile, aggregate productivity improvements in a number of industries were found to stem from reshuffling resources from less to more efficient firms as a result of trade expansion. (Pavcnik, 2000:3). When trade barriers are removed, competitive elimination of the least efficient firms is said to strike more fiercely. Estimates from turnover probabilities confirm that the likelihood of survival drops markedly when trade barriers fall and that low efficiency firms go out of business more frequently (Muendler, 2002:4).

Pavcnik (2000:6) finds that productivity improvements in Chile were indeed related to trade liberalisation and that competition forced plants in formerly shielded sectors to restructure. Most importantly, exiting plants were, on average, less productive than plants which continued to produce. Plant exit contributes to the reshuffling of resources within the economy and reallocation of market shares as well as resources from less to more efficient producers, which acts as an important channel for productivity improvements. However, even if it is granted that trade enhances productivity, competitive elimination may not occur without costs. These costs result from the exit of firms, often resulting in large relocations and displacements of labour and capital. Fears related to the costs of labour displacement and plant bankruptcies may deter governments from exposing their domestic firms to foreign competition.

### 3.2.4 Higher incentives for technological innovation

Trade can spur innovation by enhancing industrial learning, since it facilitates international exchange of technical information and can improve the efficiency of the global research efforts in different countries. One of the links between international trade and productivity is through technical knowledge spillovers (Grossman and Helpman, 1991). International trade boosts research by transmitting information, increasing competition and entrepreneurial effort, while expanding the size of the market for innovative firms. Trade encourages modern technology, increases demand for skilled labour and promotes learning-by-doing. Trade expansion may contribute to the exchange of ideas, adoption of technological knowledge and faster productivity growth.

As indicated in the preceding paragraph, trade increases a firm's incentive to engage in productivity-enhancing technological effort. In contrast, however, Rodrik (1991) finds that lower protection or higher import competition reduces a firm's investment in productivity enhancing technological upgrades. Deraniyagala and Fine (2001:2) also argue that the magnitude of gains could be fairly low. If trade reduces the domestic market shares of unshielded domestic producers without expanding their international sales, their incentives to invest in improved technology will decrease as protection ceases. This effect reduces the benefits of tariff reductions that are supposed to lower the relative prices of imported capital goods and ease access to foreign technology for domestic firms (Pavcnik, 2000:37). It is also argued that liberalisation facilitates procurement of technology; however, it is questionable whether domestic plants actually acquire better technology, because acquisition is dependent on the flexibility of the domestic labour force. Muendler (2002:1) finds that foreign technology adoption may be relatively unimportant, because the efficiency difference between foreign and domestic inputs has only a minor impact on productivity in some cases. The explanation for this result lies in the fact that foreign technology adoption takes time due to delays in learning, difficulties with factor complementarities and differences in production arrangements.

### 3.2.5 Economies of scale

Even in the context of economies of scale, the theoretical trade literature offers conflicting predictions about the evolution of plant productivity following a liberalisation episode. This conflict is especially apparent in cases where imperfect competition is present. On one hand, trade liberalisation exposes domestic producers to foreign competition, reduces their market power and may force them to expand output and move down the average cost curve, resulting in the exploitation of economies of scale. On the other hand, however, gains from economies of scale in developing countries may be unlikely, because increasing returns to scale are usually associated with import competing industries, in which output is likely to contract due to intensified foreign competition (Pavcnik, 2000:2).

## 3.3 APPROACHES TO THE STUDY OF TRADE AND PRODUCTIVITY

Three main methods have been applied to study the relationship between trade and productivity in the literature. These approaches include the macro-level, industry-level and micro-level. These three methods are discussed in sub-sections that follow, below.

### 3.3.1 The macro- level approach

The macro-level approach undertakes cross-country comparisons using growth regressions associating output growth with an aggregate measure of trade openness. The findings from these studies suggest that open economies tend to grow faster (Sachs and Warner, 1995). The difficulties plaguing measures of outward policy orientation across countries and over time are outlined in (Rodrik and Rodriquez, 2001). In particular, aggregate measures of openness fail to capture the differential incentives provided by trade protection to different industries. These studies also suffer from endogeneity bias, and a number of specification problems. The results of these studies are sensitive to the sample of countries used, as well as the time periods analysed, while the conclusions depend on whether the study employed cross-section or panel data (Harrison, 1996). The difficulties attendant to interpretation of multi-country studies on the trade growth nexus calls for attention to be focused on individual country experiences.

The concern regarding cross-country regressions is that the number of variables similarly affecting all countries is limited. In addition, many of these variables are likely to suffer from endogeneity or may be prone to mis-specification. Furthermore, many country specific variables relevant to productivity could be correlated with other regressors or may, in fact, be unobservable. Such variables include country policies or historical factors. To the extent that these do not vary over time, fixed effect estimates[38] could, in principle, be used to deal with the problem, but this is limited by the fact that cross-country time series data that are comparable are still relatively rare, especially in African countries, which has led scholars to exhibit considerable scepticism with regard to results from cross-country regressions. It is, therefore, important to assess the extent to which results from cross-country analysis hold up to more rigorous scrutiny than is possible within individual countries, where data at a lower level of aggregation would be desirable, allowing for a much more precise definition of the variables of interest (Deininger, 2003).

### 3.3.2 The industry-level approach

The industry-level approach attempts to circumvent the problems that plague cross country macro level studies by considering cross-industry regressions, in the spirit of the Solow residual regressions of total factor productivity growth on trade policy variables (Kim, 2000, and Lee, 1995) or on regressions of demand growth due to export expansion and import substitution (Nishimizu and

[38] It is suggested that this methodology could face potential problems if some of the variables that are hypothesised to cause productivity changes are time invariant, or may be changing only very slowly over time and may. If these factors change only very marginally then they cannot be easily distinguished from country level fixed effects.

Robinson, 1984). The main weakness affecting these studies is that a single productivity measure could ignore cross-plant heterogeneity, which is a stylised fact in many countries and may be useful in investigating the impact of trade on productivity. Industry level studies have also been criticised by Muendler (2002) for the inability to unmask the underlying microeconomic process, as seen in Kim (2000).

### 3.3.3 The micro-level approach

Microeconomic studies use longitudinal data to trace the effects of trade exposure on firms or plants in selected countries using regressions derived from two main sources. The first source is derived from firm output growth generated in a Solow framework on an indicator variable for the period of trade reform (Krishna and Mitra, 1998). The second is based on plant TFP measures affected by trade policy orientation in the industry (Pavcnik, 2000 and Fernandez 2003). These two approaches are able to identify the effect of trade reform in Chile and Colombia, respectively, although not without criticism. It is argued that the indicator variable for the trade reform period cannot isolate the corresponding productivity gains, because it also captures contemporaneous macroeconomic shocks (Fernandez, 2002). Most importantly, this indicator could ignore the variation in productivity across industries.

Section 3.3 reviewed the approaches mainly used to study the effect of trade on productivity. In Section 3.4, the study turns to the measurement of total factor productivity in manufacturing.

## 3.4 MEASURING TOTAL FACTOR PRODUCTIVITY

The production function approach is the most popular method used to capture productivity and the link between growth and foreign trade variables, protection measures, industry specific characteristics and macroeconomic shocks. Two types of functions are employed. The first is an aggregate value added function, while the second is a gross output function. The analysis usually starts by assuming industry $i's$ technology at time $t$ can be described by a production function of the form:

$$y_{it} = \beta_0 + \beta_n n_{it} + \beta_m m_{it} + \beta_k k_{it} + \varepsilon_{it}, \varepsilon_{it} = w_{it} + u_{it} \qquad (17)$$

Gross output is given by $y_{it}$, $n_{it}$ is labour, $m_{it}$ are intermediate raw material inputs, $k_{it}$ is the capital used in industry $i$ while, $\varepsilon_{it}$ is the industry-specific efficiency that is composed of two terms: $w_{it}$ assumed to be known by the plant, but not by the researcher, and $u_{it}$, which is the unexpected productivity shock not known to either the plant or the researcher. All these variables are also measured over each time period, $t$.

The industry productivity measure relies on the difference between an industry's actual output and predicted output. It is important to obtain consistent estimates of the coefficients in the production function. It is known that a plant's private knowledge of its productivity $(w_{it})$ affects its decisions about its choice of hiring labour, purchasing materials and investing in new capital, yet this process is unobserved by the econometrician. This information asymmetry introduces simultaneity bias[39] (Fernandez 2003:5, Pavcnik, 2000:8 and Olley and Pakes, 1996).

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[39] To analyse the simultaneity problem we need a dynamic model of firm behaviour that allows for firm specific efficiency differences that exhibit idiosyncratic changes over time (Olley and Pakes, 1996)

Simultaneity bias arises because an industry's private knowledge of its productivity affects its choice of inputs. More productive industries are more likely to hire more workers and invest in capital due to profitability, OLS estimation of a production function may lead to estimates of the input coefficients that are higher than their true values. The use of ordinary least squares for production function estimation assumes that regressors, such as labour, are treated as exogenous variables, yet input choices could indeed be endogenous. Since input choices and productivity are correlated, OLS estimates suffer from simultaneity bias (Fernandez 2003:5). Four main mechanisms have been employed to control the simultaneity problem.

The first approach is to impose a normal distribution on the unobserved heterogeneity and assume that the industry-specific efficiency is uncorrelated with the industry's choice of inputs and use maximum likelihood estimation (Tybout et al, 1991). The second mechanism is to assume that the unobserved industry specific efficiency $w_{it}$ is time-invariant, so it can be denoted by $w_i$, and estimate a fixed effects model of the form:

$$y_{it} = \beta_0 + \beta_n n_{it} + \beta_m m_{it} + \beta_k k_{it} + w_i + u_{it} \qquad (18)$$

The fixed effects model only partially solves the simultaneity problem, because it only removes the effects of the time-invariant plant productivity component (Pavcnik, 2000:8). However, during times of large structural adjustments, such as trade liberalisation, the assumption of unchanging productivity is not tenable and fixed effects methodology could generate biased estimates of the input coefficients. Moreover, if one is interested in how industry efficiency evolves over time in response to a change in the trade regime then the assumption that plant productivity is constant over time does not help in tackling the problem.

The third mechanism uses an industry specific and time-varying efficiency measure that can be captured as a quadratic function of time (Liu and Tybout (1996). In this case, the production function is specified as:

$$y_{it} = \beta_0 + \beta_n n_{it} + \beta_m m_{it} + \beta_k k_{it} + w_{it} + u_{it} \, ; w_{it} = \alpha_{1i} + \alpha_{2i} t + \alpha_{3i} t^2 \qquad (19)$$

In this framework, the production function is first estimated by fixed effects to obtain the input coefficient vector $\beta$. The residuals are then calculated by subtracting the actual from the predicted values of output, and, for each industry $i$, this residual measure is regressed on a constant, time and time squared. A productivity measure is then constructed using estimates of the coefficients from the second regression. This approach improves on the fixed effects methodology and requires a parametric specification of productivity, but is punitive, since many degrees of freedom are lost in the estimation process.

While the traditional approach is anchored by the use of instrumental variables to control simultaneity, an alternative approach was suggested by Olley and Pakes (1996) and modified by Levinsohn and Petrin (2001). This approach has found numerous applications, most notably by Pavcnik (2000:10), Fernandez (2003:12) and Driemeier, et al (2002:38). In the Olley-Pakes framework, labour and materials are assumed to be freely variable, while capital is the state variable assumed to be affected by the distribution of the productivity shock. The observed firm decision, in this case, will be a function of the firm's productivity. Inverting such a function allows for the anticipated, but unobserved, productivity shock to be controlled with the observed variables. Investment is used to model the anticipated productivity shock[40]. In this case, the inputs are divided into freely variable $n_i$ and $m_i$, while $k_i$ is the state variable. The productivity shock $w_{it}$ is also a state variable impacting the decision rules of

[40] The weakness with using investment is that the methodology requires that non-zero investment by firms should not arise. In view of this requirement, Levinsohn and Petrin (2001) employ intermediate input demand functions. The demand for electricity as an intermediate input is preferred, because electricity cannot be stored. Most importantly, energy use closely tracks the productivity term over time.

industries, while $\mu_{it}$ has no impact on firm decisions; $\mu_{it}$ is also assumed to be i.i.d. Under perfect competition, input and output prices are common across firms, making it possible to assume invertibility and write investment as a function of the two state variables.

$$i_{it} = i(w_{it}, k_{it}) \tag{20}$$

which can be inverted to yield:

$$w_{it} = i(i_{it}, k_{it}) \tag{21}$$

Equation (17), under the monotonicity assumption, can then be written as:

$$y_{it} = \beta_n n_{it} + \beta_m m_{it} + \phi_{it}(i_{it}, k_{it}) + u_{it} \tag{22}$$

where

$$\phi_{it}(i_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + w_{it}(i_{it}, k_{it}) \tag{23}$$

Different measures of logarithmic productivity can be generated using two estimation methods, depending on whether a TFP measure or a no-shock productivity measure is considered. From equation (17) our TFP measure is given as[41]:

$$w_{it} \hat{+} \mu_{it} = y_{it} - \beta_n n_{it} - \beta_m m_{it} - \beta_k k_{it} = tfp_{it} \tag{24}$$

The derivation of the productivity measure that excludes the component of the shock to output that is uncorrelated with inputs follows Olley and Pakes (1996). One approach considered in Olley and Pakes (1996) is to employ a polynomial in $i_{it}$ and $k_{it}$ in the regression of output on the variable inputs to model the qualified variation in productivity[42].

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[41] The TFP measure is essentially the "Solow" residual.

[42] A polynomial in investment and capital can be employed to help provide industry-specific and time-varying productivity. This measure does not need a specific functional form, yet it provides a tractable solution to the simultaneity problem (Driemeier, et al (2002:38).

## 3.5 ECONOMETRIC SPECIFICATION

The estimation proceeds in two steps. First, time-varying and industry specific measures of total factor productivity are obtained. Second, the channels through which manufacturing productivity interacts with foreign trade variables, protection measures, industry specific characteristics and the macroeconomic environment are modelled in a regression framework. This two step approach essentially relies on measures that exhibit significant variation across industries over time. This approach is superior to previous attempts that relied on a single change in the trade regime. The model also accounts for the potential endogeneity of trade policy by considering lagged trade measures as well as controlling for industry-specific characteristics ( Fernandez, 2002; Tybout and Westbrook, 1995 ).

Total factor productivity determinants can be investigated within a panel data context (Doornik and Hendry (2001)). A panel based model for estimating determinants of total factor productivity can be represented as:

$$tfp_{it} = x_{it}^{'}\gamma + \lambda_t + \mu_i + \nu_{it},\ t = 1.....,T, i,....,N. \qquad (25)$$

where the variables $\lambda$ and $\mu$ are time and individual specific effects and $x_{it}$ is a vector of explanatory variables. Two critical issues arise regarding the specification of the error component of the underlying model (Baltagi, 2000). The error variable for the disturbances can be designated as a one-way component. In this case, the error is composed mainly of the unobservable individual-specific effect and the remainder stochastic disturbance term. An alternative specification utilizes a two-way error component model for the disturbances, which basically composes the error term in three parts: the unobservable individual effect, the unobservable time effect and the remainder stochastic disturbance term. In this model, the time effect is individual-invariant and accounts for time-specific effects not included in the regression.

In the light of the above discussion, an error components model for the determinants of total factor productivity for the manufacturing sector can then be specified as:

$$tfp_{it} = \beta_0 + (\beta_1)' TP_{it} + (\beta_2)' X_{it} + (\beta_3)' M_{it} + \varepsilon_{it} \qquad (26)$$

Where TP is a trade policy measure, X consists of industry-level characteristics and M captures the role of macroeconomic factors, while the two way error component $\varepsilon_{it}$ is given as:

$$\varepsilon_{it} = \mu_i + \lambda_t + \nu_{it} \qquad (27)$$

where $i$ denotes the standard industrial classification for the 28 sectors from 301 to 392 and $t$ is the time period from 1980 to 2002. The symbol $\mu_i$ denotes a product-specific effect, while $\lambda_t$ denotes a time-specific effect and $\nu_{it}$ is the remainder assumed to be a white noise stochastic error term.

## 3.6 THE DATA AND VARIABLES

Productivity growth analysis is based on an industry-level panel data set of South African manufacturing firms provided by South African Statistics Authority (STATSSA), Trade and Industrial Policy Strategies Secretariat (TIPS) and the South African Reserve Bank. For each industry, data is available on production and sales revenues, input use (labour categories and raw materials), investment, exports and imports at the three digit ISIC industry code. The capital stock is measured at constant 1995 prices. The gross mark-up of an industry is the net operating surplus of that industry as a percentage of total intermediate inputs plus labour remuneration less all net indirect taxes. Intermediate imports are imports of goods and services produced elsewhere in the world, but used as inputs in the production process in industries. The export-output ratio is total exports divided by the gross total output value of domestic industries. Skill intensity is the ratio of skilled employment to total employment. Industry level machinery and equipment expenditure is measured in constant 1995 prices. Market size is the domestic sales value of industries to total industrial output. Table 18 shows sector sizes in terms of market size. The large sectors are food, motor vehicle parts and accessories and basic iron and steel.

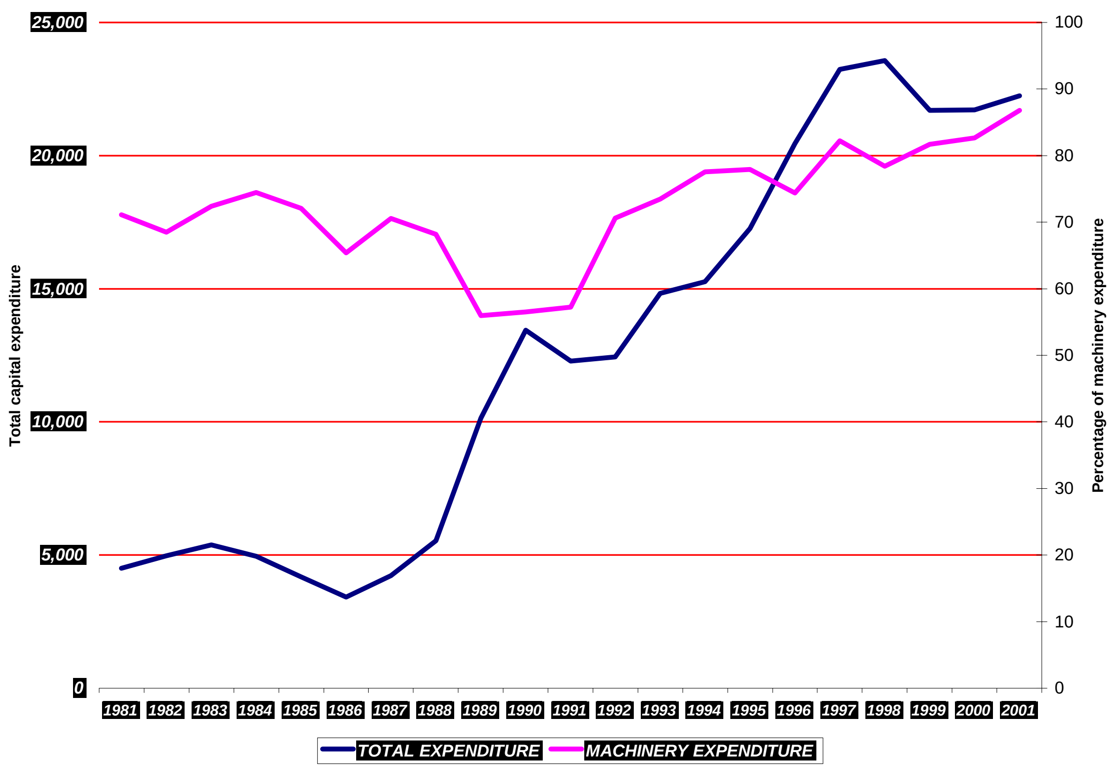
**Table 18: Proportion of industry sales to total manufacturing sales**

| CODE | SECTOR | 1995 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|
| 301 | Food (301-304) | 13.97 | 13.32 | 13.44 | 13.48 | 13.56 |
| 305 | Beverages (305) | 4.94 | 4.55 | 4.72 | 4.39 | 4.89 |
| 306 | Tobacco (306) | 2.09 | 1.69 | 1.83 | 1.82 | 1.89 |
| 311 | Textiles (311-312) | 2.89 | 2.27 | 2.19 | 2.19 | 2.03 |
| 313 | Wearing apparel (313-315) | 3.19 | 2.35 | 2.17 | 2.02 | 2.12 |
| 316 | Leather & leather products (316) | 0.58 | 0.60 | 0.56 | 0.54 | 0.50 |
| 317 | Footwear (317) | 0.86 | 0.50 | 0.39 | 0.36 | 0.35 |
| 321 | Wood & wood products (321-322) | 1.92 | 2.02 | 2.02 | 2.07 | 2.20 |
| 323 | Paper & paper products (323) | 5.18 | 2.80 | 2.61 | 2.57 | 2.37 |
| 324 | Printing, publishing & recorded media (324-326) | 3.02 | 2.61 | 2.45 | 2.27 | 2.48 |
| 331 | Coke & refined petroleum products (331-333) | 4.70 | 6.93 | 7.31 | 7.40 | 6.06 |
| 334 | Basic chemicals (334) | 4.23 | 4.83 | 5.02 | 5.09 | 4.80 |
| 335 | Other chemicals & man-made fibres (335-336) | 6.06 | 5.88 | 5.88 | 5.78 | 5.94 |
| 337 | Rubber products (337) | 1.18 | 1.04 | 1.06 | 1.09 | 1.10 |
| 338 | Plastic products (338) | 2.75 | 2.42 | 2.44 | 2.47 | 2.60 |
| 341 | Glass & glass products (341) | 0.71 | 0.51 | 0.57 | 0.54 | 0.55 |
| 342 | Non-metallic minerals (342) | 2.57 | 2.47 | 2.43 | 2.36 | 2.45 |
| 351 | Basic iron & steel (351) | 6.96 | 7.48 | 7.09 | 7.92 | 8.53 |
| 352 | Basic non-ferrous metals (352) | 2.28 | 3.47 | 3.58 | 3.54 | 3.09 |
| 353 | Metal products excluding machinery (353-355) | 6.44 | 5.52 | 5.51 | 5.58 | 5.74 |
| 356 | Machinery & equipment (356-359) | 5.21 | 4.39 | 4.35 | 4.40 | 4.67 |
| 361 | Electrical machinery (361-366) | 3.17 | 2.94 | 2.78 | 2.76 | 2.82 |
| 371 | Television & communication equipment (371-373) | 0.96 | 1.04 | 0.72 | 0.73 | 0.85 |
| 374 | Professional & scientific equipment (374-376) | 0.40 | 0.31 | 0.33 | 0.33 | 0.34 |
| 381 | Motor vehicles, parts & accessories (381-383) | 11.12 | 12.04 | 12.94 | 13.06 | 12.75 |
| 384 | Other transport equipment (384-387) | 0.61 | 1.40 | 1.24 | 1.18 | 1.21 |
| 391 | Furniture (391) | 1.49 | 1.40 | 1.24 | 1.18 | 1.21 |
| 392 | Other industries (392) | 0.55 | 3.24 | 3.13 | 2.89 | 2.89 |
| | TOTAL | 100 | 100 | 100 | 100 | 100 |

Note: Data covers the entire manufacturing sector
Source: Quantec Research, Trade and Industry Policy Strategies, www.tips.org.za

Tariffs are the sum of customs payments divided by the value of imports. The real effective exchange rate of the Rand $(RER)$with base year 1995 is identified as series KBP5036J in the Reserve Bank Quarterly Bulletin Time Series. Inflation is defined as the change in the consumer price index published by Statistics South Africa (STATSSA). Another interesting variable is machinery and equipment expenditure in the manufacturing sector. Evidence in Figure 9 shows a steady increase in this variable as a proportion of total capital expenditure especially in the most recent past.

**Figure 9: Manufacturing machinery and equipment expenditure, 1980-2001.**




Note: Data is for the entire manufacturing sector.

Source: Regression output, www.statssa.gov.za

Table 19 contains the descriptive statistics of the key variables used in the estimation process. It shows a degree of heterogeneity in some of the key variables. For example, the mean export share is 13.4 per cent, covering a range marginally in excess of 0.2 per cent up to a maximum of 67 per cent. Import penetration also exhibits heterogeneity with a mean penetration rate of 20.4 per cent, a minimum of 0.5 per cent and a maximum of 89 per cent. Industry Capacity utilisation is relatively more stable. The mean capacity utilisation rate is 82 per cent, the maximum recorded is 97 per cent with a standard deviation of 6.2.

**Table 19: Descriptive statistics for productivity variables**

| Variable | Definition | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| EX | Export share | 13.40 | 13.79 | 0.23 | 66.95 |
| MZ | Import penetration | 20.35 | 17.47 | 0.53 | 89.07 |
| GM | Gross mark up | 18.54 | 20.63 | 0.69 | 202.77 |
| IM | Intermediate imports | 11.24 | 7.44 | 0.83 | 83.05 |
| MS | Market share | 3.57 | 3.19 | 0.31 | 14.71 |
| TARIFF | Customs duties paid | 6.84 | 6.48 | 0.06 | 42.96 |
| RAD | Machinery expenditure | 70.31 | 16.99 | 9.13 | 98.57 |
| RER | Real exchange rate | 97.13 | 15.01 | 59.8 | 129.3 |
| SKILL | Skill intensity | 36.23 | 12.85 | 9.58 | 76.14 |
| TOT | Terms of trade | 101.28 | 6.27 | 93.56 | 121.83 |
| CPI | Consumer price index | 73.83 | 45.41 | 14.90 | 157.80 |
| CAP | Capacity utilisation | 82.03 | 6.16 | 62.3 | 97.33 |
| | **Memorandum Items** | | | | |
| I | Number of Industries | | | | 28 |
| T | Number of Periods | | | | 23 |
| N | Number of observations | | | | 644 |

Note: For each industry, intermediate imports are generated as a ratio of intermediate imports to total output, the tariff variable is derived as the ratio of customs duties paid to imports, research and development is captured by the ratio of total machinery expenditure to total gross fixed investment.
Source: Regression output, www.statssa.gov.za, www.tips.org.za and www.reservebank.co.za.

## 3.7 ECONOMETRIC RESULTS

### 3.7.2 Estimating TFP determinants using static panel data estimators

Two results are presented in this section. In Table 20, findings from applying the maximum likelihood procedure are provided; while in Table 21 results from estimating total factor productivity determinants using fixed effects within regression are reported.

The expectation is that increased export shares should associate positively with total factor productivity. Import penetration ratios are expected to affect productivity positively if industries lower costs and become more efficient when import competition increases (Fernandez, 2003). However, if imports are endogenous with respect to domestic industries' productivity, a negative correlation may arise. A negative correlation arises because some import competing industrial chapters attract imports by being relatively less productive. The reduction in tariffs is also expected to impact positively on industrial productivity growth.

Furthermore, an increase in intermediate imports, increased skill intensity and growth in investment in machinery and equipment should impact positively on productivity. However, an appreciation in the real exchange rate or an increase in inflation should associate negatively with industry productivity performance. An increase in capacity utilisation should be positively related to manufacturing productivity[43].

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[43] TFP growth is likely to be sensitive to the business cycle because capital and labour inputs are difficult to adjust in the short-run, output fluctuations will be related to fluctuations in import and export shares. To deal with this simultaneity problem capacity utilisation is used as a dependent variable (Gunnar and Subramanian, 2000).

In the light of the expectations indicated above, Table 20 presents the results of the random effects maximum likelihood regression. The results show that the export output ratio had a positive and statistically significant relationship with total factor productivity. A one per cent increase in the export output ratio would increase total factor productivity by 0.78 per cent. Miller and Uphadhay (2000) reach a similar conclusion, namely, more openness associates with high total factor productivity using an aggregate sample that included African countries. Gunnar and Subramanian (2000) employing aggregate time series South African manufacturing data finds that a 10 percentage point increase in openness associated with an increase in total factor productivity by 5 per cent in the long run.

The increase in import penetration had a significant negative association with the level of total factor productivity, suggesting that imports may be endogenous with respect to productivity in some domestic industries. A one per cent increase in the import penetration ratio would decrease total factor productivity by 0.63 per cent. It seems imports are being attracted to manufacturing sectors with relatively less productive industries. In contrast Bjurek and Durevall (1998) using Zimbabwean manufacturing industry data report that an increase by one percentage point in imports raised total factor productivity by 0.2 percentage points.

Increases in market size had a negative impact on total factor productivity, indicating that productivity gains were higher for smaller industrial sectors. A one per cent increase in the market share would decrease total factor productivity by 0.26 per cent. Trade liberalisation seems to bring a decline in inefficiency rents that benefit small industrial sectors.

Investment in equipment and machinery is used to proxy technology acquisition, since South African industries do not engage in substantial research and development activity, the bulk of research and development is likely to be embodied in capital equipment, as expected this variable had a positive and significant association with productivity. A one per cent increase in the machinery and equipment expenditure would increase total factor productivity by 0.48 per cent. A similar finding is reported in Gunnar and Subramanian (2000) where a 10 percentage point increase in the share of machinery and equipment investment was associated with an increase in total factor productivity by 3 per cent. The use of intermediate imports also represents an interaction between South African firms and the outside world. An increased use of intermediates had a positive and significant impact on productivity. A one percent increase in the intermediates would increase total factor productivity by 1.12 per cent.

The tariff variable[44] was significant but wrongly signed, suggesting that a one per cent increase in the tariffs would increase total factor productivity by 0.07 per cent. This is counter to the findings of Gunnar and Subramanian (2000) in which it was indicated that annual growth rate in total factor productivity was nearly 3 percentage points higher in sectors where tariffs were reduced by 10 per cent compared with sectors where tariffs were unchanged. In the same thrust, Brazilian data suggests that the effect of nominal tariffs can be identified after controlling for endogeneity of nominal tariffs. The estimated coefficient for tariffs in the productivity equation was negative, even when a measure of tariffs on inputs was added to the productivity equation; the associated coefficient on tariffs on inputs remained negative. The key message is that there is a huge degree of heterogeneity of responses to trade liberalisation and that the effect of

[44] This results suggests the need to employ the effective industry nominal tariff rates themselves in empirical work. Fernandez (2003) reports a negative association between tariff rates and productivity. Productivity gains were associated with tariff declines. This again emphasises the need to employ tariff rates.

tariff reductions depends heavily on the observed and unobserved characteristics of the industries (Schor, 2004).

Capacity utilisation had an insignificant impact on productivity performance. Current levels of inflation and the real exchange rate had an insignificant impact on productivity. However, a real exchange rate depreciation should increase the demand for and profitability of traded industries out put. Therefore, real exchange rate changes that stimulate exports and limit imports associate with higher total factor productivity. In Zimbabwe, Bjurek and Durevall (1998) report that increases in inflation reduced manufacturing total factor productivity, explaining the empirical regularity between higher inflation and lower economic growth (Miller and Uphadhay, 2000).

The model in Table 21 also allows for interactions between variables in the estimation process. A number of interactions were found to be important for productivity. The first important block of interactions dealt with openness as measured by the export-output ratio. In this block the interaction between export output ratio and market shares had a positive and significant impact on productivity. Within this block, the interaction between export output ratio and the real exchange rate has a negative and significant impact on total factor productivity. The other interaction in this group is between export-output ratios and inflation, this interaction had a negative and significant association with manufacturing productivity performance.

The second vital block of interactions dealt with openness as measured by import penetration. The interaction between import penetration and market share impacted negatively on productivity. Within this block, interactions between the real exchange rate and inflation with import penetration had positive and significant effects on productivity. The interaction with the tariff measure impacted negatively on industrial productivity performance.

The third category concerns the interplay between machinery and equipment with other measures. In this group, it is only the relationship with the real exchange rate variable that had a negative and significant impact on manufacturing productivity. The fourth class of interactions captures the fundamental role of the rapport between other variables and intermediates on productivity. The significant associations in this case are between intermediates and market share as well as between intermediates and the real exchange rate. The latter had a negative effect while the former has a positive impact on productivity.

The final group of interactions deals with trade measures and levels of skill intensity in industrial sectors, the two associations are significant. It is however, the interaction between import penetration and skill intensity that is found to connect positively and in a statistically significant way with productivity performance. This latter finding may be related to that in Miller and Uphadhay (2000) and indicates the fundamental role of trade in encouraging the use of skilled labour. To check the robustness of the results in Table 20, the determinants of total factor productivity in manufacturing are examined in Table 21 in a fixed effects regression framework.

**Table 20: Estimating TFP determinants by maximum likelihood regression**

| Random effects ML regression: Dependent Variable TFP | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Coefficient. | Std. Err. | Z | P>\|z\| | [95% Interval] | Conf. |
| Export output ratio | 0.7751 | 0.1887 | 4.11 | 0.000 | 0.4052 | 1.1451 |
| Import penetration ratio | -0.6257 | 0.2105 | -2.97 | 0.003 | -1.0384 | -0.2132 |
| Market size | -0.2639 | 0.0941 | -2.80 | 0.005 | -0.4485 | -0.0794 |
| Machinery expenditure | 0.4659 | 0.1938 | 2.40 | 0.016 | 0.0859 | 0.0846 |
| Intermediate imports | 1.1152 | 0.2014 | 5.53 | 0.000 | 0.7203 | 1.5101 |
| Tariff | 0.0697 | 0.0169 | 4.13 | 0.000 | 0.0366 | 0.1028 |
| Capacity utilisation | 0.1677 | 0.1065 | 1.57 | 0.115 | -0.0410 | 0.3764 |
| Rand real exchange rate | -0.0579 | 0.2179 | -0.27 | 0.790 | -0.4851 | 0.3691 |
| Inflation | -0.8011 | 1.0747 | -0.75 | 0.456 | -2.9075 | 1.3052 |
| Export output ratio × market share | 0.0579 | 0.0114 | 5.08 | 0.000 | 0.0355 | 0.0802 |
| Export output ratio × real exchange rate | -0.1254 | 0.0363 | -3.45 | 0.001 | -0.1967 | -0.0542 |
| Export output ratio × inflation | -0.7002 | 0.1725 | -4.06 | 0.000 | -1.0384 | -0.3620 |
| Import penetration ratio × market share | -0.0122 | 0.0154 | -0.79 | 0.428 | -0.0423 | 0.0179 |
| Import penetration ratio × real exchange rate | 0.0937 | 0.0438 | 2.14 | 0.032 | 0.0078 | 0.1795 |
| Import penetration ratio × tariff | -0.0267 | 0.0065 | -4.09 | 0.000 | -0.0396 | -0.0139 |
| Import penetration ratio × inflation | 0.0403 | 0.1939 | 2.08 | 0.038 | 0.0232 | 0.7832 |
| Machinery expenditure × market share | -0.0134 | 0.0128 | -1.05 | 0.295 | -0.0385 | 0.0117 |
| Machinery expenditure × real exchange rate | -0.1126 | 0.0431 | -2.61 | 0.009 | -0.1972 | -0.0281 |
| Machinery expenditure × inflation | 0.0276 | 0.1969 | 0.14 | 0.889 | -0.3585 | 0.4137 |
| Intermediate imports × market share | 0.0449 | 0.0146 | 3.08 | 0.002 | 0.0163 | 0.0735 |
| Intermediate imports × real exchange rate | -0.2331 | 0.0451 | -5.17 | 0.000 | -0.3215 | -0.1447 |
| Intermediate imports × inflation | -0.1791 | 0.1816 | -0.99 | 0.324 | -0.5349 | 0.1767 |
| Export output ratio × skill intensity | -0.0616 | 0.0225 | -2.74 | 0.006 | -0.1056 | -0.0175 |
| Import penetration ratio × skill intensity | 0.0458 | 0.0216 | 2.13 | 0.034 | 0.0036 | 0.0881 |
| Constant | -0.1462 | 1.0658 | -0.14 | 0.891 | -2.2351 | 1.942 |
| /sigma_u | 0.0708 | 0.0149 | 4.74 | 0.000 | 0.0415 | 0.1001 |
| /sigma_e | 0.1228 | 0.0037 | 32.78 | 0.000 | 0.1155 | 0.1301 |
| Rho= | 0.2496 | 0.0816 | | | 0.1190 | 0.4317 |
| Group variable | | sector | Number of obs | | | 589 |
| Time variable | | year | Number of groups | | | 28 |
| Log Likelihood | | 370.538 | LR chi2 (24) | | | 243.44 |
| Random effects | | gaussian | Chibar2(01) | | | 23.71 |
| Prob>chi² | | 0.0000 | Prob>=chibar2 | | | 0.000 |

Source: Estimation results by the author
Note: Detailed variable definitions are provided in Appendix A.3.

As in Table 20, the results in Table 21 show that the export output ratio had a positive and statistically significant relationship with manufacturing total factor productivity, while the increase in import penetration had a significant negative association with productivity performance. Increases in market size impacted negatively on the evolution of manufacturing productivity. A rise in investment in equipment and machinery by industries generated a robust improvement in manufacturing productivity. An increased application of intermediate imports also had a positive and significant impact on total factor productivity. Again the tariff variable was significant but wrongly signed. Capacity utilisation had a positive but insignificant impact on the evolution of manufacturing productivity, while inflation and the real exchange rate had negative but insignificant impacts on the pattern of industrial productivity.

The results for the interactions were also broadly similar. The interaction between export-output ratio and market shares had positive impact on industrial productivity. The interaction between export output ratios and real exchange rate as well as that between the export output ratio and inflation had negative and significant associations with manufacturing productivity. The interaction between import penetration and tariffs showed a negative and significant association with productivity performance. Machinery and the real exchange rate interaction had a negative impact on productivity, while the interaction between real exchange rate and intermediates associated negatively with productivity. Again, the effect of import penetration and skill intensity is found to be positive and significant, a similar result to that reported in Table 20.

**Table 21: Estimating TFP determinants by fixed effects within regression**

| Random effects within regression: Dependent Variable TFP | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Coefficient. | Std. Err. | Z | P>\|z\| | [95% Interval] | Conf. |
| Export output ratio | 0.8556 | 0.2122 | 4.03 | 0.000 | 0.4388 | 1.2725 |
| Import penetration ratio | -0.8196 | 0.2245 | -3.35 | 0.001 | -1.3001 | -0.3391 |
| Market size | -0.3385 | 0.1162 | -2.91 | 0.004 | -0.5668 | -0.1103 |
| Machinery expenditure | 0.4572 | 0.1997 | 2.29 | 0.022 | 0.0648 | 0.0849 |
| Intermediate imports | 1.1171 | 0.2107 | 5.55 | 0.000 | 0.7566 | 1.5846 |
| Tariff | 0.0839 | 0.0201 | 4.17 | 0.000 | 0.0444 | 0.1236 |
| Capacity utilisation | 0.1471 | 0.1211 | 1.21 | 0.225 | -0.0908 | 0.3851 |
| Rand real exchange rate | -0.0683 | 0.2223 | -0.31 | 0.759 | -0.5059 | 0.3693 |
| Inflation | -2.0253 | 1.1266 | -1.80 | 0.073 | -4.2382 | 0.1876 |
| Export output ratio × market share | 0.0584 | 0.0135 | 4.32 | 0.000 | 0.0318 | 0.0849 |
| Export output ratio × real exchange rate | -0.1245 | 0.0380 | -3.28 | 0.001 | -0.1991 | -0.0498 |
| Export output ratio × inflation | -0.6709 | 0.1848 | -3.63 | 0.000 | -1.0341 | -0.3077 |
| Import penetration ratio × market share | -0.0109 | 0.0231 | -0.47 | 0.638 | -0.0562 | 0.0344 |
| Import penetration ratio × real exchange rate | 0.0946 | 0.0448 | 2.11 | 0.035 | 0.0066 | 0.1825 |
| Import penetration ratio × tariff | -0.0308 | 0.0078 | -3.90 | 0.000 | -0.0463 | -0.0153 |
| Import penetration ratio × inflation | 0.4226 | 0.2019 | 2.09 | 0.037 | 0.0259 | 0.8192 |
| Machinery expenditure × market share | 0.0013 | 0.0154 | 0.09 | 0.932 | -0.0289 | 0.0316 |
| Machinery expenditure × real exchange rate | -0.1210 | 0.0442 | -2.74 | 0.006 | -0.2078 | -0.0342 |
| Machinery expenditure × inflation | 0.1453 | 0.2057 | 0.71 | 0.480 | -0.2587 | 0.5494 |
| Intermediate imports × market share | 0.0415 | 0.0178 | 2.33 | 0.020 | 0.0066 | 0.0765 |
| Intermediate imports × real exchange rate | -0.2450 | 0.0469 | -5.22 | 0.000 | -0.3372 | -0.1528 |
| Intermediate imports × inflation | -0.2021 | 0.1898 | -1.07 | 0.287 | -0.5749 | 0.1706 |
| Export output ratio × skill intensity | -0.0929 | 0.0295 | -3.15 | 0.002 | -0.1501 | -0.0350 |
| Import penetration ratio × skill intensity | 0.1010 | 0.0375 | 2.69 | 0.007 | 0.0272 | 0.1747 |
| Constant | 0.3042 | 1.0967 | 0.28 | 0.782 | -1.8502 | 2.4587 |
| /sigma_u | 0.1177 | | | | | |
| /sigma_e | 0.1243 | | | | | |
| Rho= | 0.4729 | (fraction of variance due to u_i) | | | | |
| Group variable | | sector | Number of groups | | | 28 |
| Time variable | | year | Number of groups | | | 28 |
| R-sq within | | 0.3910 | Corr(u_i,xb) | | | -0.7424 |
| Number of obs | | 589 | Test that all u_i=0 | | | F(27,537)=4.58 |
| F(24,537) | | 14.36 | Prob>F | | | 0.000 |

Source: Estimation results by the author
Note: Detailed variable definitions are provided in Appendix A.3.

## 3.8 CONCLUDING REMARKS

Increased trade affected productivity performance in South African industries. The results in Tables 20 and 21 show an important association between openness measures and productivity. Increased competition in foreign markets through export exposure benefits industry productivity. The benefits to productivity arise due to pressures for reduction in inefficiency and to lower costs from the exposure to more advanced technologies. The results also show a negative impact of import penetration on industry productivity. The estimated coefficient shows evidence that some import competing industrial chapters are relatively less productive, yielding a negative relationship between import penetration and productivity.

The increased import of cheaper intermediate inputs is an important mechanism for industry level productivity gains. The data set has information on imported intermediate inputs and industries did differ in the degree to which production relied on imported inputs. The effect of intermediate imports on productivity is positive and statistically significant.

The results also cast some light on the issue of productivity and technology acquisition. Data on machinery and equipment purchases at the industry level is employed to estimate this effect. Machinery and equipment investment is indeed crucial for productivity gains in the light of trade expansion. The results show that machinery investment had positive effects on productivity.

The analysis also models the impact of interactions on productivity. The key findings are that the interaction between export-output ratio and market shares impacted on productivity in a positive and significant manner. The interaction between export output ratios and the real exchange rate had a negative impact on manufacturing productivity. The effect of the interaction between export-output ratio and inflation on productivity was negative. When import penetration and tariffs are interacted, there is a negative association with productivity. The machinery and the real exchange rate interaction impacts negatively on total factor productivity. The interaction between imported intermediates and market share impacted positively on productivity, while that with the real exchange rate and inflation impacted negatively on manufacturing productivity.

In conclusion, the analysis in Chapter 3 indicates important directions for policy. Most significantly, the results suggest positive payoffs for industrial productivity of an appropriately managed liberalisation of the external sector. Liberalisation of the external sector is good for competition and learning. Learning is available through increased access to world class intermediate inputs and technology. The findings also indicate that some macroeconomic variables interact with trade policy measures to affect industrial performance. In terms of future research directions, it would be interesting to examine the issue of productivity at a much lower classification level than the three digit categorisation. Such research should employ plant level rich data sets that were generated by the manufacturing censuses of 1991, 1993 and 1996 to examine issues related to trade, industry concentration and efficiency in South Africa as has been implemented in Ivory Coast (Harrison, 1994).

After examining the issue of trade and productivity in Chapter 3, the impact of trade on derived labour demand is investigated in Chapter 4. While this issue is of critical significance, relatively few studies in Africa have examined this problem. Using South African trade and industrial data sets, an attempt is made to shed some light on these issues.