CAHIER DE RECHERCHE ♯0905E
Département de science économique
Faculté des sciences sociales
Université d'Ottawa

WORKING PAPER ♯0905E
Department of Economics
Faculty of Social Sciences
University of Ottawa

Total Factor Productivity growth, Technological Progress, and Efficiency Changes: Empirical Evidence from Canadian Manufacturing Industries*

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April 2009

* I would like to thank seminar participants at the University of Ottawa for their valuable comments and suggestions.
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Abstract

As productivity (growth) appears to be the single most important determinant of a nation's living standard or its level of real income over long periods of time, it is important to better understand the sources of productivity growth. In Canada, total factor productivity (TFP) growth is the major contributing factor (relative to changes in capital intensity) to labour productivity growth, particularly in manufacturing sector. However, the TFP gap is also the main source of labour productivity gap between Canada and other industrialized (OECD) countries in recent years. In this paper, a stochastic frontier production model is applied to Canadian manufacturing industries to investigate the sources of TFP growth. Using a comprehensive panel data set of eighteen industries over the period 1990-2005 and the approach proposed by Kumbhakar et al. (1991) and Kumbhakar and Lovell (2000), we decompose TFP growth into technological progress, changes in technical efficiency, changes in allocative efficiency and scale effects. The decomposition reveals that during the period under study, technological progress has been the main driving force of productivity growth, while negative efficiency changes observed in certain industries have contributed to reduce average productivity growth. In addition, our empirical results show that research and development (R&D) expenditure and information and communications technology (ICT) investment, as well as trade openness exert a positive impact on productivity growth through the channel of efficiency gains. We argue that the decomposition carried out in this study may be very helpful to elicit the correct diagnosis of Canada's productivity problem and develop effective policies to reverse the situation, and thereby reduce Canada's lagging productivity gap.

Keywords: *Canadian manufacturing, Stochastic frontier, TFP growth, Efficiency changes.*
JEL classifications: *L6**,** O16, O47.*

Résumé
Comme la (croissance de la) productivité semble être le plus important déterminant de l'évolution du niveau de vie d'un pays ou de son niveau de richesse à long terme, il est primordial de mieux comprendre les sources de croissance de la productivité. Au Canada, la croissance de la productivité totale des facteurs (PTF) est le facteur qui contribue le plus (par rapport au changement de l'intensité de capital) à la croissance de la productivité de travail, en particulier dans le secteur manufacturier. Cependant, l'écart de la PTF est également la principale source d'écart de productivité de travail entre le Canada et d'autres pays industrialisés (OCDE) au cours des dernières années. Dans ce papier, un modèle de frontière de production stochastique est appliqué aux industries manufacturières canadiennes pour étudier les sources de croissance de la PTF. En utilisant un ensemble de données de panel de dix-huit industries au cours de la période 1990-2005 et l'approche proposée par Kumbhakar et al. (1991) et Kumbhakar et Lovell (2000), nous décomposons la croissance de la PTF en progrès technologique, en changements d'efficience technique, en changements d'efficience allocative et en changements d'échelle. La décomposition révèle que sur la période de l'étude, le progrès technologique a été le principal moteur de la croissance de la productivité, alors que les changements négatifs d'efficiences observés dans certaines industries ont contribué pour réduire la croissance moyenne de la productivité. En outre, nos résultats empiriques indiquent que la dépense en recherche et développement (R-D) et l'investissement en technologies de l'information de la communication (TIC), aussi bien que l'ouverture commerciale exercent un impact positif sur la croissance de la productivité par le biais des gains d'efficience. Nous soutenons du fait que la décomposition effectuée dans cette étude peut être très utile pour obtenir le vrai diagnostic du problème de la productivité du Canada et de développer des politiques efficaces pour améliorer la situation, et réduire de ce fait l'écart de la productivité du Canada.

Mots Clés : *Industries manufacturières canadiennes; Frontière de production stochastique; Croissance de la PTF; Changements d'efficience.*

Classification JEL : *L6**,** O16, O47*

1 Introduction

In the productivity literature, total factor productivity (TFP) growth is most commonly computed via the growth accounting framework, or the growth regression approach. In the first case, TFP growth is derived residually as a measure of output growth that cannot be accounted for by inputs growth. In the second case, parametric approaches are applied by relating economic growth to a list of potential explanatory variables to obtain direct measure of TFP growth. Neither methodology decomposes TFP growth into its components.

However, Aigner *et al.* (1977) and Meeusen and van den Broeck (1977) simultaneously proposed a stochastic frontier production model that allows decomposing TFP growth into two components: technological progress (TP) and change in technical efficiency (TE). The former reflects the improvement stemming from innovation and the diffusion of new knowledge and technologies, while the latter measures the movement of production towards the frontier. A notable advantage of the stochastic frontier is the fact that the restrictive assumptions about firms operating with full efficiency are relaxed. Studies that assume that firms operate with full efficiency ignore the potential contribution of efficiency changes to TFP growth, which leads to biased and misleading results. Hence, the analysis conducted in this paper overcomes this assumption.

The stochastic frontier model has been intensively used to decompose TFP growth at the firm, industry, state, and even more at the national levels. Although a vast number of empirical applications have contributed to identify the source of TFP growth by focusing on its decompositions, representative studies are Nishimizu and Page (1982), Kumbhakar (1990), Fecher and Perelman (1992), Domazlicky and Weber (1998), to mention only a few. Some studies have extended their analysis to deal with issues such as scale effects and allocative efficiency change. By applying a flexible stochastic translog function, Kumbhakar and Lovell (2000), Kim and Han (2001) and Sharma *et al.* (2007) decompose TFP growth into its components: technological progress, changes in technical efficiency, changes in allocative efficiency and scale effects.

Following the aforementioned studies, the objective of this paper is to decompose TFP growth in the Canadian manufacturing industries (TFP growth is the major contributing factor to labour productivity growth) using the stochastic frontier approach. Having a detailed panel data set of eighteen three-digit manufacturing industries from 1990-2005, we break down TFP growth in Canadian manufacturing industries into its components. To the best of our knowledge, none of the existing studies for Canadian manufacturing has decomposed the TFP growth. However, decomposing the TFP growth into technological progress and efficiency changes is important to better understand whether gains in industry productivity levels are achieved through the efficient use of inputs or through technological progress. From this perspective, we argue that the decomposition carried out in this study may be very helpful to elicit the correct diagnosis of Canada's productivity problem and develop effective policies to reverse the situation, and thereby reduce Canada's lagging productivity gap.

The rest of the paper is organized as follows. The next section outlines the stochastic frontier production function and methodology employed to decompose TFP growth. Following this, data and variable definitions are presented. Section 4 presents the empirical results and discusses sensitivity analysis. The last section contains some concluding remarks.

2 The Stochastic Frontier Production Function and TFP growth Decomposition

Stochastic Frontier model was pioneered by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977) and extended by Pitt and Lee (1981), Schmidt and Sickles (1984), Kumbhakar (1990) and Battese and Coelli (1992, 1995) to allow for panel data estimation, in which technical efficiency and technological progress vary over time and across production units. In this section, however, we describe the methodology used in the efficiency literature for estimating stochastic frontier production and the decomposition of TFP growth. In line with Bauer (1990), Kumbhakar *et al.* (1991) and Huang and Liu (1994), we begin with a stochastic frontier model which can be estimated with panel data, in which inefficiency effects can be expressed as a specific function of explanatory variables:

$$y_{i,t} = f(x_{i,t}, t, \beta) exp(v_{i,t} - u_{i,t}) \tag{1}$$

where $y_{i,t}$ denotes the output produced by industry i in year t, $x_{i,t}$ is the corresponding matrix of explanatory variables and β is a vector of parameters to be estimated. The $v_{i,t}$'s are random errors assumed to be independent and identically distributed with mean zero and variance . The $u_{i,t}$ are non-negative random variables associated with technical inefficiency of production, which are assumed to be independently distributed, such that $u_{i,t}$ are obtained by truncation at zero of the normal distribution with mean $z_{i,t}\delta$ and variance σ_u^2 . Thus, the technical inefficiency effects $u_{i,t}$ in the stochastic frontier model (1) can be specified as follows:

$$u_{i,t} = z_{i,t}\delta + w_{i,t} \tag{2}$$

where $z_{i,t}$ is the matrix of explanatory variables associated with the technical inefficiency effects of industry i in year t, δ is a vector of unknown parameters to be estimated, and $w_{i,t}$ are defined by truncation of the normal distribution with zero mean and variance σ^2 Given the specification in equation (2), the technical inefficiency level of production of unit i at time t is then defined as[1]

$$TE_{i,t} = exp(-u_{i,t}) = exp(-z_{i,t}\delta - w_{i,t}) \tag{3}$$

Note that the technical efficiency index varies between zero and one. A measure equal to one indicates that a firm operates with full efficiency given combinations of inputs and the state of technology. Technical efficiency below one means the production process is not optimal.

Nevertheless, when using the parametric method to estimate the production efficiency, the functional form for the production function should be specified. This study chooses a translog specification for the production frontier in equation (1). A great advantage of using this specification is that it does not require imposing general restrictions on parameters, and secondly, it allows us to evaluate the contribution of scale change and allocative efficiency to TFP. The translog stochastic frontier production function can be written in terms of logarithms as follows:

$$\begin{aligned}\ln y_{i,t} = \beta_0 + \beta_t t + \frac{1}{2}\beta_{t,t}t^2 + \sum_j \beta_j \ln x_{j,i,t} + \sum_j \beta_{t,j} t \ln x_{i,j,t} \\ + \frac{1}{2}\sum_j \sum_k \beta_{j,k} \ln x_{j,i,t} \ln x_{k,i,t} + v_{i,t} - u_{i,t}, \;\; j,k = L, K\end{aligned} \tag{4}$$

In equation (4), $x_{j,i,t}$ and $x_{k,i,t}$ represent the variable inputs t, k to the production process. The stochastic frontier production, defined by equation (4), and the technical inefficiency effects, specified by equation (2), can be jointly estimated by the maximum-likelihood estimation (MLE) using the software such as FRONTIER, LIMDEP. In this paper, however, we prefer to employ FRONTIER 4.1

[1]The prediction of the technical efficiency is derived based on its conditional expectation; given the observable value of $(v_{i,t} - u_{i,t})$. For complete review refer to the appendix in Battese and Coelli (1993).

(see Coelli, 1996) to estimate the stochastic frontier model. Once the stochastic frontier is estimated, then an index of technological progress can be easily evaluated by differentiating equation (4) with respect to time, yielding:

$$TP_{i,t} = \frac{\partial f(x,t,\beta)}{\partial t}, \;\; j = L, K \tag{5}$$

and the associated output elasticites for capital and labour can be estimated empirically based on the following equation[2]:

$$\epsilon_j = \frac{\partial f(x,t,\beta)}{\partial x_j}, \;\; j,k = L, K \tag{6}$$

Next, to decompose TFP growth, we begin by fully differentiating the deterministic component of equation (1) with respect to time:

$$\dot{y} = \frac{\partial f(x,t,\beta)}{\partial t} + \sum_j \frac{\partial \ln f(x,t,\beta)}{\partial x_j}\frac{dx_j}{dt} - \frac{du}{dt} \tag{7}$$

Equation (7) can be rewritten in the following form:

$$\dot{y} = TP - \frac{du}{dt} + \sum_j \epsilon_j \dot{x}_j \tag{8}$$

where $\dot{x}_j$ denote the growth rate of factor inputs, and, ϵ_j, are as defined previously.

TFP growth can be obtained by subtracting the weighted growth of factor inputs from the growth rate of output.

$$T\dot{F}P = \dot{y} - \sum_j s_j \dot{x}_j \tag{9}$$

Here s_j is the input share in the production costs. Substituting equation (8) into (9) and after some algebraic manipulations, we get:

$$T\dot{F}P = TP - \frac{du}{dt} + (\epsilon - 1)\sum_j \xi_j \dot{x}_j + \sum_j (\xi_j - s_j)\dot{x}_j \tag{10}$$

where $\epsilon = \sum_j \epsilon_j$, and $\xi_j = \epsilon_j/\epsilon$. Equation (10) is the decomposition of TFP growth (see Kumbhakar and Lovell, 2000). Now, from equation (10), we can see easily that TFP growth is split into four components: technological progress, the

[2] Observe that elasticites are obtained after partially differentiating equation (4) with respect to capital and labour.

change in technical efficiency, the change in the scale of production, the change in allocative efficiency (The last term in square brackets). If the assumption of constant returns to scale holds, the third term on the right-hand side cancels out, if there are increasing returns to scale, changes in the quantity of inputs contribute positively to the growth of TFP. In the case of decreasing returns to scale, the reasoning is straightforward. As mentioned above, the last term on the right-hand side of equation (10) represents the change in allocative efficiency; with specific measures of inputs shares, it is possible to determine the contribution of factor allocation into the TFP growth.

3 Data and Variable Definitions

The data used in this empirical analysis were obtained mainly from Statistics Canada. The data cover eighteen three-digit manufacturing industries for the years 1990-2005. The GDP series are constructed from two base sources: Time series of GDP at basic price in 1997 chained-Fisher dollars from 1997 onward are extracted from the CANSIM II table 379-0017 and are extended back to 1990 using the growth rates of GDP from the CANSIM II table 379-0001. We utilized total capital stock in 1997 chained-Fisher dollars-the private fixed non-residential geometric (infinite) end-year net stock from the CANSIM II table 0321-0002. For data on labour input, we combined hours worked data from the CANSIM II tables 383-0022 and 383-0010. However, where there is overlap, we have drawn from the database CANSIM II table 383-0010.

We include in the matrix z_{it} some variables which may influence the efficiency of the firm (or industry) to take account of Research and Development (R&D)-intensity, Information and Communications Technology (ICT)-intensity, Machinery and Equipment (M&E)-intensity, Openness, and Skills[3].

The R&D expenditure data are taken from the Science, Innovation and Electronic Information Division of Statistics Canada. The North American Industrial Classification System (NAICS)-based data from 1994 onwards are extended back to 1990 using the growth rates of Standard Industrial Classification (SIC)-based data and then deflated using the GDP deflator. The time series of ICT capital stock in 1997 chained-Fisher dollars are obtained from the Investment and Capital

[3]R&D intensity: real intramural R&D expenditure to GDP ratio; ICT and M&E intensity are defined respectively as ICT/GDP and M&E/GDP. Openness is defined as real import plus export to GDP ratio and Skills is the hours worked by workers with university degree and above to the total hours worked

Stock Division of Statistics Canada for the years, 1990-2004, which are extrapolated linearly to 2005. The series of M&E capital stock in 1997 chained-Fisher dollars are downloaded from the CANSIM II table 0321-0002. The trade data are collected from Industry Canada Trade Data Online; data from 1992 onwards are NAICS-based, which are extended back to 1990 using the growth rates of SIC-based data and then deflated using the GDP deflator. Share of hours worked by workers with a university degree are obtained from Industry Canada for the years, 1990-2000. The data were extrapolated geometrically forward to 2005.

We assembled total compensation per hour worked data from the CANSIM II table 383-0003 and 383-0010 and nominal interest rates series from the Bank of Canada—the Government of Canada benchmark bond yields-10 year. We used the GDP deflator to construct both real wages and real interest rates.

4 Empirical Results

4.1 *Tests of Hypotheses*

Before commenting on the parameter estimates of the stochastic frontier production function and the inefficiency effects model, we perform various tests on the stochastic production function and the inefficiency effects model: Tests on the selection of functional form, the one-sided test on the inefficiency effects, and the non-neutral technological progress hypotheses are discussed in turn.

First of all, we applied a generalized likelihood ratio test to decide between the null hypotheses of traditional Cobb Douglas functional form versus the alternative of the translog specification. The value of log-likelihood functions obtained from the estimation of the Cobb Douglas and translog representation are 86.31 and 182.23, respectively. When we employed the likelihood ratio test, a value of 191.84 was found, which is significantly greater than the critical Chi square table value of 14.07 with 7 degrees of freedom at the five percent level of significance. On the basis of this statistic, we reject the null hypothesis, thus, translog specification is favored over the Cobb Douglas representation.

Second, with regard to the case of inefficiency effects, we test the null hypothesis of no technical inefficiency against the alternative of the presence of inefficiency effects. Note that the null hypothesis asserts that all the coefficients of the technical inefficiency model are zero. By imposing this restriction on the original model, a value of likelihood ratio test of 49.21 was obtained. This statistics is higher than the mixed[4] Chi square value of 13.40. The result provides evidence that technical inefficiency effects are present in the Canadian Manufacturing sector.

The last test we have conducted in this exercise consists of testing the null hypothesis that there is no technological change over time. It implies that all the parameters in equation (5) do not belong to the stochastic frontier model. To test this hypothesis, a generalized likelihood ratio test is applied. The log-likelihood function for the unrestricted model (equation (4)) is 182.23, and with the imposition of the restriction, a value of 113.42 was obtained. Thus, the value of the generalized likelihood ratio test is 137.62, which is significantly higher than the critical value of 9.49 at five percent probability level. As a result, the null hypothesis of no technological progress over time is rejected.

4.2 *Maximum Likelihood Estimates*

The maximum likelihood estimates for the translog stochastic frontier production function and the technical inefficiency effects model are reported in Table 1. At first glance, the variance parameter γ, is highly significant and close to one, revealing that a great percentage of the disturbance term is due to the presence of technical inefficiency, as was already examined by the likelihood ratio test.

Concerning the other estimated parameters, the majority of the estimated coefficients in the stochastic translog production function are significant at conventional levels. Indeed, although some of the interaction and squared terms turned out to be non-significant, the generalized likelihood ratio test carried out earlier rejected the Cobb Douglas function as an adequate representation of the data. However, it is widely recognized that in translog representation, there is high level of multicollinearity due to the interaction and squared term, which causes certain estimated coefficient to be non-significant.

Regarding the technical inefficiency effects model, most of the parameter estimates are highly significant, and with expected signs. Surprisingly, the estimated coefficient on M&E capital intensity does not provide a plausible economic interpretation. It enters positively to the model. Note that a positive estimated coefficient means negative gains in technical efficiency and negative effects on output growth. Thus, the positive sign on M&E capital intensity is counterintuitive. Second, our results also found an increase in the share of hours worked by workers with a university degree does not enhance technical efficiency; consequently, it

[4] When distributions are mixed Chi square, the critical values for the likelihood-ratio test are obtained from Table 1 of Kodde and Palm (1986).

Table 1: Maximum Likelihood Estimates for Parameters of the Stochastic Production Frontier and Technical Inefficiency Effects Model

Variables	Parameter	Coefficient	Standard error
Stochastic Frontier Model			
Intercept	β_0	-39.247^a	6.587
Time	β_1	0.059*	0.059
Capital	β_k	0.853^b	0.371
Labour	β_l	4.347^a	0.629
Capital^2	$\beta_{k,k}$	-0.041^c	0.022
Labour^2	$\beta_{l,l}$	-0.210^a	0.034
Time^2	β_2	-0.001*	0.001
Capital*Labour	$\beta_{k,l}$	0.019*	0.019
Time*Capital	$\beta_{t,k}$	0.007^a	0.002
Time*Labour	$\beta_{t,l}$	-0.010^a	0.004
Inefficiency Effects Model			
Intercept	δ_0	-4.303^a	0.105
R&D intensity	δ_1	-3.492^a	0.569
M&E intensity	δ_2	1.805^a	0.090
ICT intensity	δ_3	-8.449^a	1.673
Openness	δ_4	-0.098^a	0.031
Skills	δ_5	8.071^a	0.809
Variance parameters			
Sigma-squared	σ_u^2	0.241^a	0.00002
Gamma	γ	0.958^a	0.005
Log-likelihood		182.235	
LR-test of the one-sided error		49.212	
Observations		288	

^{a,b,c} indicate that coefficients are statistically significant at one, five and ten percent level of significance respectively, and * stands for non significant.

has harmful effects on output growth.

4.3 *Decomposition Results*

The TFP growth rates calculations with the average growth of technological progress (TP), change in technical efficiency (TE), the scale change (SC), and the allocative efficiency change (AC), as well as their respective standard deviations are summarized in Table 2. A complete listing of the estimates of TFP change, technological progress, Change in technical efficiency, change in the scale and change in allacative efficiency are provided, respectively in Table A1 through A5 in Appendix. Note that TFP growth is not calculated as residual but is obtained by summing its components. Column 1 of Table 2 shows the annual average growth rates of TFP over the 1990-2005 period. The Furniture & Related, Primary Metal, Transportation Equipment and Computer & Electronic are those with the highest average growth rates, whilst Apparel & Leather, Textile and Printing the lowest ones.

With respect to technological progress in column (3) all Canadian manufacturing industries have realized positive growth rates during the period, technological progress was the major contributing factor to TFP growth for the Canadian manufacturing industries. The highest technological progress was attained in Petroleum & Coal with a growth rate of 4.43%. Although technological progress has shown an improvement, it is offset by low rate of technical efficiency change (column 5). The deterioration in technical efficiency change was the main cause for the low and declining rate of TFP growth in the Petroleum & Coal sector.

Examining the contribution of technical efficiency change to TFP growth, it is noteworthy that only six industries, Primary Metal, Paper, Computer & Electronic, Transportation Equipment, Chemical and Furniture & Related enjoyed a positive growth rate of technical efficiency over the period. Note that a positive growth rate of technical efficiency indicates a movement toward the production frontier, which also means an increase in output growth. The remaining industries suffered from a declining technical efficiency over the period. It reveals that inputs have not been used effectively in these industries.

The contribution of the change in the scale of production and allocative efficiency to TFP growth is reported respectively in columns 7 and 9. The scale component exerted a positive effect on the TFP growth of Petroleum & Coal, Furniture & Related, Miscellaneous, Plastics & Rubber, Machinery and Wood, although its magnitude was small. Allocative efficiency contributes moderately to the TFP growth of the Furniture & Related product sector, whilst the lowest allocative efficiency was registered for Paper, with an average annual growth rate of -1.18%. The presence of allocative inefficiency in the Paper, Textile, Primary Metal, Apparel & Leather and Chemical industries reveals that inputs were not allocated properly in these sectors. The empirical evidence suggests that input prices did not equate the value of their marginal product.

Table 3 reports the estimated technical efficiency scores. A complete technical efficiency level estimate for industries is presented in Table A6 in Appendix. Column 1 presents the average annual levels of technical efficiency for each industry during the period of 1990-2005. Technical efficiency in 1990, 2000 and

2005 are reported respectively in Columns 3, 5 and 7. Each column reporting technical efficiency estimates is followed by a column providing a ranking. The last two columns record the change in ranking between 1990-2000 and 1990-2005. The ranking measures the shift of an industry relative to other industry given a base year. An industry becomes technically efficient if the estimated technical efficiency moves closer to one.

In 1990, the industries in the top four positions of the technical efficiency ranking list were Printing, Electrical Equipment, Machinery, and Wood. The industries in the last four positions were Textile, Paper, Primary Metal, and Plastics & Rubber. Among the last four industries in the ranking list in 1990, only Paper and Primary Metal have noticeably increased their technical efficiency level.

However, it is important to highlight the ranking of the Computer & Electronic industry. In 1990, the Computer & Electronic was ranked in position 14, with estimated technical efficiency level of 0.91. In 2000, it moved to position 1 with a spectacular increase in technical efficiency. A possible explanation of the rapid amelioration of technical efficiency in this sector could be the high exposure to international competition, which force the Computer & Electronic to use its inputs optimally in order to improve its efficiency and TFP growth. By contrast, the Petroleum & Coal registered the greatest decline in technical efficiency level, by moving from 0.93 in 1990 to 0.74 in 2000 and to 0.46 in 2005. It is noteworthy that this sharp decline over time has contributed negatively to the TFP growth of the Petroleum & Coal sector.

Finally, it appears that the manufacturing sector as whole has shown a decrease of 2.8 percentage points, by moving from 0.91 in 1990 to 0.88 in 2005. In 1990, five industries that lie below the average value were Textile, Paper, Primary Metal, Plastics & Rubber and Computer & Electronic whereas, in 2005, six industries fall below the average value.

Table 2: Average Annual growth rates of Total factor productivity and the growth of its components, 1990-2005

Industry	TFP growth (%)	Std of TFP change	Technological progress (%)	Std of TP change	Technical efficiency (%)	Std of TE change	Scale efficiency (%)	Std of scale change	Allocative efficiency (%)	Std of AE change
Food, Beverage & Tobacco	1.714	0.0118	1.922	0.0031	-0.269	0.013	-0.046	0.0040	0.135	0.0087
Textile	1.036	0.0408	2.338	0.0029	-0.053	0.035	-0.564	0.0113	-0.659	0.0153
Apparel & Leather	0.164	0.0248	1.092	0.0030	-0.083	0.015	-0.348	0.0050	-0.483	0.0215
Wood	2.900	0.0200	2.307	0.0032	-0.165	0.027	0.010	0.0040	0.781	0.0238
Paper	2.194	0.0354	3.133	0.0039	0.356	0.039	-0.079	0.0009	-1.181	0.0130
Printing	1.353	0.0211	1.722	0.0030	-0.628	0.021	-0.002	0.0033	0.284	0.0123
Petroleum & Coal	1.978	0.0404	4.432	0.0037	-3.180	0.073	0.330	0.0302	0.430	0.0229
Chemical	2.612	0.0130	3.042	0.0026	0.037	0.008	-0.052	0.0013	-0.391	0.0128
Plastics & Rubber	2.839	0.0219	2.118	0.0036	-0.081	0.016	0.121	0.0029	0.716	0.0131
Nonmetallic Mineral	2.373	0.0276	2.539	0.0032	-0.323	0.020	-0.060	0.0112	0.245	0.0163
Primary Metal	3.183	0.0233	3.056	0.0032	0.908	0.021	-0.136	0.0024	-0.612	0.0176
Fabricated Metal	1.940	0.0166	1.652	0.0037	-0.045	0.008	-0.071	0.0029	0.434	0.0156
Machinery	2.516	0.0216	1.690	0.0027	-0.029	0.012	0.015	0.0022	0.861	0.0175
Computer & Electronic	2.962	0.0391	2.232	0.0024	0.355	0.020	-0.012	0.0043	0.411	0.0326
Electrical Equipment	1.729	0.0333	2.116	0.0020	-0.073	0.007	-0.467	0.0127	0.167	0.0224
Transportation Equipment	3.019	0.0191	2.383	0.0023	0.069	0.012	-0.079	0.0035	0.666	0.0165
Furniture & Related	3.283	0.0334	1.346	0.0026	0.022	0.009	0.289	0.0118	1.644	0.0232
Miscellaneous	2.600	0.0238	1.562	0.0034	-0.045	0.013	0.276	0.0125	0.827	0.0220

Note: A positive sign on technical efficiency change means a movement towards the frontier.

Table 3: Technical efficiency level estimates by industry and year

Industry	Average efficiency level 1990-2005	Rank based on average value	Efficiency estimate in 1990	Rank in 1990	Efficiency estimate in 2000	Rank in 2000	Efficiency estimate in 2005	Rank in 2005	Change in rank 1990-2000	Change in rank 1990-2005
Food, Beverage & Tobacco	0.935	10	0.961	5	0.921	11	0.921	12	-6	-7
Textile	0.734	18	0.724	18	0.803	17	0.716	17	1	1
Apparel & Leather	0.935	9	0.945	10	0.952	8	0.932	10	2	0
Wood	0.906	14	0.961	4	0.894	14	0.936	9	-10	-5
Paper	0.767	17	0.752	17	0.808	16	0.805	16	1	1
Printing	0.916	11	0.976	1	0.909	13	0.881	14	-12	-13
Petroleum & Coal	0.823	16	0.937	12	0.744	18	0.460	18	-6	-6
Chemical	0.952	3	0.953	7	0.957	6	0.959	3	1	4
Plastics & Rubber	0.913	13	0.895	15	0.923	10	0.882	13	5	2
Nonmetallic Mineral	0.913	12	0.930	13	0.916	12	0.881	15	1	-2
Primary Metal	0.866	15	0.792	16	0.884	15	0.928	11	1	5
Fabricated Metal	0.951	4	0.959	6	0.960	5	0.952	7	1	-1
Machinery	0.962	2	0.967	3	0.970	3	0.963	1	0	2
Computer & Electronic	0.948	6	0.909	14	0.983	1	0.962	2	13	12
Electrical Equipment	0.965	1	0.967	2	0.976	2	0.957	4	0	-2
Transportation Equipment	0.945	8	0.943	11	0.965	4	0.954	5	7	6
Furniture & Related	0.95	5	0.949	8	0.956	7	0.953	6	1	2
Miscellaneous	0.946	7	0.948	9	0.938	9	0.941	8	0	1
Average	0.905		0.913		0.913		0.885			

Table 4 gives the average elasticities estimates and their respective standard deviations for each industry over the period of 1990-2005 as well as the average elasticity across all industries. Averaging elasticity of capital and labour for the manufacturing sector are respectively, 0.389 and 0.708. Adding elasticities across all industries yield 1.096, which implies that the manufacturing sector is characterized by increasing returns to scale. Within the manufacturing sector, the production technology exhibits decreasing returns to scale in the Food, Beverage & Tobacco and Transportation Equipment, constant returns to scale in the Wood, Paper, Fabricated Metal and Machinery and increasing returns to scale in the remaining industries.

The industry with the highest capital elasticity is Furniture & Related, product followed by Machinery, and the lowest is Petroleum & Coal followed by Paper. Conversely, the highest value for labour elasticity is found for Petroleum & Coal followed by Textile and the lowest for Food, Beverage & Tobacco followed by Transportation Equipment.

Table 4: Elasticites estimates

Industry	Capital ϵ_k	Std of Cap. ϵ_k	Labour ϵ_l	Std of Lab. ϵ_l	RTS	Std of RTS
Food, Beverage &Tobacco	0.374	0.0338	0.497	0.0562	0.871	0.0234
Textile	0.415	0.0366	0.831	0.0397	1.246	0.0128
Apparel & Leather	0.459	0.0368	0.665	0.0384	1.125	0.0147
Wood	0.380	0.0328	0.650	0.0672	1.030	0.0366
Paper	0.337	0.0417	0.693	0.0438	1.030	0.0056
Printing	0.387	0.0336	0.703	0.0541	1.090	0.0214
Petroleum & Coal	0.333	0.0361	1.071	0.0667	1.404	0.0362
Chemical	0.346	0.0337	0.708	0.0410	1.055	0.0103
Plastics & Rubber	0.397	0.0325	0.672	0.0807	1.069	0.0486
Nonmetallic Mineral	0.397	0.0339	0.803	0.0613	1.199	0.0304
Primary Metal	0.347	0.0378	0.717	0.0415	1.064	0.0087
Fabricated Metal	0.409	0.0328	0.588	0.0818	0.996	0.0504
Machinery	0.413	0.0308	0.619	0.0606	1.032	0.0313
Computer & Electronic	0.375	0.0302	0.702	0.0526	1.077	0.0247
Electrical Equipment	0.385	0.0315	0.811	0.0379	1.196	0.0167
Transportation Equipment	0.354	0.0299	0.543	0.0521	0.897	0.0243
Furniture & Related	0.450	0.0262	0.699	0.0802	1.149	0.0561
Miscellaneous	0.450	0.0326	0.764	0.0714	1.214	0.0397
Average	0.389		0.708		1.096	

Note: Capital and labour are averaged. ϵ_k and ϵ_l denote elasticity of capital and labour, respectively.

5 Concluding Remarks

Many commentators in Canadian academic and policy circles argue that to better understand productivity trends and to design guidelines to promote productivity performance over long periods of time, it is crucial to identify the sources of productivity growth. In this paper, we apply a stochastic frontier production model to Canadian manufacturing industries, to investigate the sources of total factor productivity growth.

First, the decomposition results reveal that during the period under study, technological progress has been the main driving force of productivity growth, while negative efficiency changes observed in certain industries have contributed to pulling productivity down.

Second, the empirical results show that Research and Development (R&D) expenditure and Information and Communications Technology (ICT) investment, as well as trade openness exert a positive impact on economic growth by channel of efficiency gains.

Third, the result shows that there is no positive relationship between M&E-intensity and efficiency gains. Furthermore, we find that an increase in the share of hours worked by workers with a university degree does not enhance technical efficiency of an industry.

Finally, the rate of technological progress (the most relevant component in the TFP growth decomposition), changes in technical efficiency, changes in allocative efficiency and scale effects are all important in determining the improvement of TFP growth.

Thus, we speculate that the decomposition undertakes in this study provides more insights into the better understanding of the contribution of technological progress and efficiency changes to the enhancement of economic performance, and facilitate the way policy makers implement industrial policies.

APPENDIX

Tables in Appendix provide results by industry and year.

Table A1: Total Factor Productivity Growth Estimates by industry and year in percent

Industry	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Food, Beverage & Tobacco	2.49	2.38	1.33	2.16	1.77	2.29	-0.52	3.73	-0.23	3.12	2.08	1.59	0.01	1.65	1.86
Textile	-2.24	2.23	0.79	6.30	4.29	-0.64	5.60	7.67	1.23	5.45	-1.89	-2.83	-3.98	-0.88	-5.56
Apparel & Leather	1.88	3.03	-0.37	4.45	2.70	-0.76	2.59	0.71	-0.44	0.89	-4.51	-1.09	-1.19	-2.31	-3.13
Wood	1.33	1.78	3.10	3.81	1.66	1.47	3.89	5.10	2.39	7.07	-1.55	3.86	1.81	3.47	4.31
Paper	-1.37	5.57	8.31	4.34	-2.24	3.29	1.48	0.82	7.24	4.26	-3.29	4.97	0.92	-0.97	-0.42
Printing	3.43	1.64	1.51	0.94	-0.58	0.39	1.71	0.67	0.58	7.06	3.55	-1.62	0.27	-0.72	1.47
Petroleum & Coal	-3.85	4.29	1.83	7.23	3.80	2.26	4.38	5.86	-0.78	-1.24	10.12	0.59	-4.46	-0.04	-0.30
Chemical	0.25	2.47	3.46	2.32	1.44	2.60	2.62	3.57	4.93	4.50	2.18	1.93	4.13	1.58	1.18
Plastics & Rubber	-0.90	5.26	4.12	4.91	2.71	4.20	3.98	4.14	4.58	5.53	1.63	2.16	0.65	0.46	-0.86
Nonmetallic Mineral	-5.12	0.10	0.68	2.45	2.41	3.12	5.52	6.68	3.19	5.42	2.36	1.97	3.55	1.08	2.20
Primary Metal	2.53	8.01	5.37	1.45	1.23	2.40	3.77	6.37	3.46	6.22	1.05	0.74	0.29	2.71	2.17
Fabricated Metal	-0.25	0.82	0.43	3.69	3.60	3.57	3.41	4.43	3.89	1.76	0.49	0.28	0.32	0.52	2.13
Machinery	1.15	1.66	4.26	7.47	3.61	3.53	4.92	4.01	1.94	1.67	0.78	-1.00	0.17	0.77	2.79
Computer & Electronic	2.41	2.90	1.56	5.4	4.00	2.17	5.38	4.95	8.17	11.62	0.36	-4.17	1.33	-2.07	0.43
Electrical Equipment	0.73	0.57	1.65	1.65	0.84	0.80	1.78	6.56	8.17	7.14	3.66	-2.40	-1.54	-1.64	-2.02
Transportation Equipment	2.02	1.30	5.80	6.12	4.16	2.96	5.27	3.96	4.47	0.89	-0.30	1.21	3.20	1.80	2.45
Furniture & Related	-1.93	2.47	1.95	4.80	3.51	5.00	9.73	7.98	6.16	6.54	0.46	-0.67	0.36	1.71	1.16
Miscellaneous	1.80	1.15	2.47	9.87	1.99	4.08	1.34	2.46	1.82	2.62	-0.69	1.70	1.08	2.43	4.85

Table A2: Technological progress estimates by industry and year in percent

Industry	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Food, Beverage & Tobacco	2.35	2.35	2.29	2.23	2.18	2.12	2.08	1.90	1.88	1.76	1.74	1.68	1.64	1.57	1.51	1.48
Textile	2.73	2.70	2.72	2.62	2.55	2.46	2.45	2.42	2.37	2.31	2.17	2.13	1.97	2.02	1.94	1.84
Apparel & Leather	1.31	1.42	1.46	1.36	1.38	1.34	1.27	1.23	1.18	1.09	0.90	0.74	0.74	0.74	0.68	0.64
Wood	2.79	2.84	2.69	2.53	2.46	2.51	2.44	2.36	2.33	2.15	2.13	2.06	1.95	1.92	1.87	1.87
Paper	3.66	3.65	3.59	3.51	3.39	3.31	3.30	3.24	3.19	3.04	2.98	2.87	2.76	2.67	2.52	2.45
Printing	2.07	2.11	2.09	2.07	1.99	1.89	1.81	1.77	1.73	1.63	1.56	1.46	1.41	1.37	1.30	1.29
Petroleum & Coal	4.94	5.00	4.93	4.73	4.71	4.65	4.61	4.43	4.31	4.26	4.15	4.18	4.22	3.99	3.86	3.95
Chemical	3.40	3.41	3.34	3.27	3.22	3.14	3.03	3.03	3.07	3.03	3.03	2.95	2.87	2.71	2.62	2.56
Plastics & Rubber	2.65	2.65	2.59	2.47	2.37	2.28	2.20	2.12	2.11	2.03	1.91	1.88	1.76	1.68	1.62	1.56
Nonmetallic Mineral	2.96	2.98	2.95	2.85	2.77	2.73	2.58	2.58	2.56	2.50	2.39	2.33	2.23	2.14	2.05	2.03
Primary Metal	3.54	3.56	3.52	3.40	3.27	3.12	3.07	3.03	2.98	2.95	2.91	2.89	2.71	2.68	2.63	2.61
Fabricated Metal	2.11	2.12	2.17	2.04	1.94	1.83	1.76	1.70	1.68	1.63	1.41	1.35	1.27	1.20	1.13	1.10
Machinery	2.00	2.03	2.01	1.94	1.97	1.82	1.78	1.74	1.70	1.70	1.56	1.52	1.41	1.34	1.27	1.24
Computer & Electronic	2.59	2.60	2.51	2.48	2.43	2.27	2.24	2.17	2.11	2.15	2.12	2.21	2.16	2.04	1.86	1.77
Electrical Equipment	2.33	2.40	2.37	2.35	2.30	2.23	2.17	2.07	2.12	2.04	2.07	2.00	1.95	1.93	1.80	1.74
Transportation Equipment	2.66	2.73	2.64	2.58	2.56	2.50	2.47	2.45	2.42	2.31	2.26	2.19	2.14	2.15	2.05	2.01
Furniture & Related	1.62	1.69	1.72	1.61	1.54	1.49	1.44	1.41	1.33	1.29	1.23	1.14	1.04	1.03	1.01	0.96
Miscellaneous	1.87	1.90	2.00	1.94	1.93	1.79	1.73	1.71	1.62	1.49	1.32	1.24	1.17	1.08	1.09	1.12

Table A3: Technical efficiency change estimates by industry and year in percent

Industry	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Food, Beverage & Tobacco	-0.02	-0.36	-0.40	0.24	-0.21	-0.86	-2.58	0.71	-2.56	2.06	1.26	-0.78	-1.39	0.48	0.36
Textile	-3.95	2.74	-1.92	2.54	2.57	-5.52	1.97	4.47	-1.35	6.36	-1.31	-1.43	-3.40	1.39	-3.95
Apparel & Leather	-1.80	0.19	-0.99	-0.20	1.78	-0.95	1.60	-0.23	-2.32	3.69	-0.75	0.33	0.61	-0.84	-1.36
Wood	-0.43	-0.11	-1.20	-3.38	-6.25	-2.04	-0.16	3.87	0.64	2.30	-0.94	4.91	0.52	0.74	-0.95
Paper	-5.75	2.65	6.11	1.94	-7.18	0.32	-0.84	0.23	5.40	2.80	-3.89	5.44	-1.07	-0.67	-0.15
Printing	-1.11	-0.58	-1.69	-1.04	-0.34	-2.80	-0.27	-3.44	-0.60	5.21	2.51	-1.54	-1.88	-1.14	-0.70
Petroleum & Coal	-0.12	-0.41	-5.30	4.92	1.19	1.14	-4.16	0.84	-5.79	-11.63	10.79	-4.56	-19.93	-9.83	-4.88
Chemical	-1.96	-0.31	0.90	1.28	0.63	-0.59	0.29	-0.34	-0.58	1.08	0.10	0.44	-0.59	0.31	-0.10
Plastics & Rubber	-1.77	2.51	2.58	1.00	-1.61	0.77	-1.36	-1.27	0.69	1.27	-0.30	1.37	-1.14	-1.28	-2.69
Nonmetallic Mineral	-4.54	2.51	1.57	-0.67	-0.79	-1.18	3.14	0.28	-2.37	0.75	1.35	-0.80	-0.34	-1.94	-1.81
Primary Metal	-2.55	5.17	4.07	0.73	-0.84	-0.39	-1.04	2.98	-0.78	1.90	1.84	1.40	0.03	-0.93	2.06
Fabricated Metal	-1.22	0.35	-0.19	1.05	-0.09	-1.18	-0.41	-0.54	0.59	1.72	-0.52	0.30	-0.37	-0.33	0.17
Machinery	-2.85	-0.73	2.89	0.92	0.20	-0.67	0.11	-0.30	-0.04	0.75	-0.05	-0.35	-0.29	-0.08	0.06
Computer & Electronic	1.41	1.16	-0.28	1.71	1.38	-1.39	1.19	0.88	1.27	0.13	-3.64	-3.55	3.85	0.21	0.98
Electrical Equipment	-0.94	-0.23	0.81	0.62	-0.36	0.58	0.24	0.2	-0.75	0.74	-0.41	-1.05	-1.24	-0.22	0.91
Transportation Equipment	-2.10	-0.58	2.53	0.81	-0.13	-1.00	0.10	0.05	2.27	0.22	-1.47	-0.12	-0.24	0.61	0.08
Furniture & Related	-2.22	1.75	-0.02	0.68	0.43	-0.17	-0.61	0.35	-0.51	0.95	0.49	-0.29	-1.24	0.30	0.44
Miscellaneous	0.59	0.69	-0.32	-1.38	-0.27	-1.33	1.46	1.06	-3.07	1.56	0.18	1.96	-0.46	-0.19	-1.14

Table A4: Change in scale of production estimates by industry and year in percent

Industry	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Food, Beverage & Tobacco	0.19	-0.08	0.09	0.11	0.04	-0.15	-0.98	-0.12	-0.86	0.57	0.27	-0.06	-0.04	0.13	0.22
Textile	-0.96	-2.78	0.61	0.65	0.07	0.49	0.21	0.25	0.09	-0.32	-1.33	-0.16	-2.72	-1.57	-0.99
Apparel & Leather	-0.94	-0.67	0.18	0.19	-0.32	-0.18	-0.14	-0.15	0.38	0.19	-0.12	-0.94	-1.17	-0.6	-0.93
Wood	-1.29	0.22	0.48	0.45	0.25	0.08	0.06	-0.07	0,00	-0.02	0.00	0.00	-0.01	0.00	-0.01
Paper	-0.10	-0.15	-0.20	-0.01	0.11	-0.07	-0.06	-0.23	0.02	-0.08	-0.08	-0.14	0.00	-0.03	-0.15
Printing	-0.47	-0.52	-0.04	0.27	-0.21	0.63	-0.05	0.46	0.18	0.17	0.17	-0.38	0.00	-0.09	-0.15
Petroleum & Coal	-3.34	-1.00	2.30	-3.81	-2.43	-2.58	2.68	0.66	0.48	3.38	-2.44	0.52	6.87	3.52	0.15
Chemical	-0.21	-0.05	-0.07	-0.25	-0.22	0.08	-0.13	-0.04	0.20	-0.02	-0.06	-0.09	0.18	-0.05	-0.06
Plastics & Rubber	-0.68	0.05	0.05	0.45	0.46	0.24	0.53	0.28	0.23	0.21	-0.04	0.03	0.01	0.00	0.00
Nonmetallic Mineral	-2.23	-2.47	-1.24	0.26	0.08	1.26	-0.44	0.91	0.90	0.84	-0.32	0.35	0.56	0.43	0.21
Primary Metal	-0.12	-0.51	-0.26	-0.28	0.08	-0.07	0.18	0.04	0.07	0.10	-0.55	-0.08	-0.39	0.08	-0.33
Fabricated Metal	-0.36	-0.82	0.06	0.20	0.21	0.11	0.01	-0.05	-0.06	-0.57	0.06	0.06	0.03	-0.04	0.07
Machinery	-0.31	-0.45	-0.07	0.34	0.44	0.16	0.13	0.06	-0.07	0.02	-0.03	0.00	0.00	0.00	0.00
Computer & Electronic	-0.81	0.00	-0.34	0.26	0.48	0.12	0.36	0.31	0.33	0.72	-0.31	-0.59	-0.43	-0.05	-0.22
Electrical Equipment	-2.04	-1.53	-1.48	-0.71	-0.37	-0.80	0.12	0.59	2.70	0.72	0.73	-1.31	-1.41	-0.40	-1.79
Transportation Equipment	0.40	-0.08	-0.17	-0.49	-0.61	-0.28	-0.61	-0.20	-0.33	0.51	0.26	0.28	0.19	-0.08	0.04
Furniture & Related	-2.20	-1.87	0.85	1.11	0.46	1.07	2.22	1.57	1.05	0.76	-0.07	0.01	-0.21	-0.23	-0.18
Miscellaneous	-1.17	-2.15	0.30	2.95	0.81	1.26	-0.93	0.15	1.83	1.05	-0.44	-0.28	0.36	-0.16	0.57

Table A5: Change in Allocative efficiency estimates by industry and year in percent

Industry	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Food, Beverage & Tobacco	-0.03	0.52	-0.59	-0.37	-0.18	1.22	1.14	1.27	1.43	-1.24	-1.13	0.79	-0.12	-0.48	-0.20
Textile	-0.03	-0.46	-0.52	0.56	-0.80	1.94	0.99	0.58	0.18	-2.76	-1.38	-3.21	0.12	-2.64	-2.46
Apparel & Leather	3.19	2.06	-0.92	3.08	-0.10	-0.90	-0.10	-0.08	0.41	-3.89	-4.39	-1.22	-1.37	-1.55	-1.47
Wood	0.21	-1.02	1.28	4.29	5.15	1.00	1.62	-1.03	-0.41	2.66	-2.67	-3.00	-0.61	0.86	3.40
Paper	0.83	-0.53	-1.11	-0.98	1.52	-0.26	-0.85	-2.36	-1.22	-1.44	-2.19	-3.09	-0.68	-2.79	-2.58
Printing	2.91	0.64	1.18	-0.28	-1.91	0.74	0.27	1.92	-0.63	0.11	-0.58	-1.11	0.77	-0.79	1.04
Petroleum & Coal	-5.38	0.77	0.10	1.41	0.39	-0.91	1.43	0.05	0.26	2.85	-2.41	0.41	4.61	2.42	0.47
Chemical	-0.99	-0.51	-0.65	-1.93	-2.11	0.09	-0.57	0.89	2.29	0.42	-0.81	-1.29	1.83	-1.31	-1.22
Plastics & Rubber	-1.10	0.12	-0.98	1.08	1.58	0.98	2.69	3.03	1.63	2.14	0.09	-0.99	0.09	0.11	0.26
Nonmetallic Mineral	-1.33	-2.89	-2.50	0.08	0.39	0.47	0.25	2.93	2.16	1.44	-1.00	0.20	1.18	0.54	1.76
Primary Metal	1.64	-0.17	-1.84	-2.26	-1.13	-0.21	1.60	0.37	1.22	1.31	-3.14	-3.29	-2.04	0.92	-2.18
Fabricated Metal	-0.80	-0.88	-1.49	0.50	1.65	2.87	2.09	3.34	1.73	-0.79	-0.40	-1.35	-0.54	-0.23	0.79
Machinery	2.29	0.83	-0.50	4.24	1.14	2.26	2.94	2.55	0.35	-0.66	-0.67	-2.05	-0.87	-0.42	1.49
Computer & Electronic	-0.79	-0.78	-0.29	1.00	-0.13	1.21	1.66	1.66	4.41	8.65	2.10	-2.20	-4.13	-4.10	-2.11
Electrical Equipment	1.31	-0.03	-0.03	-0.55	-0.67	-1.15	-0.64	3.65	4.18	3.62	1.33	-1.99	-0.82	-2.82	-2.88
Transportation Equipment	1.00	-0.68	0.85	3.24	2.40	1.77	3.33	1.69	0.21	-2.10	-1.27	-1.09	1.11	-0.77	0.32
Furniture & Related	0.81	0.88	-0.49	1.47	1.14	2.65	6.71	4.73	4.34	3.61	-1.11	-1.43	0.78	0.63	-0.06
Miscellaneous	0.48	0.62	0.55	6.37	-0.35	2.42	-0.89	-0.37	1.57	-1.30	-1.67	-1.14	0.10	1.70	4.31

Table A6: Estimated levels of Technical efficiency

Industry	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Food, Beverage & Tobacco	0.96	0.96	0.96	0.95	0.96	0.95	0.95	0.92	0.93	0.9	0.92	0.93	0.93	0.91	0.92	0.92
Textile	0.72	0.68	0.71	0.69	0.72	0.74	0.69	0.71	0.75	0.74	0.8	0.79	0.78	0.74	0.76	0.72
Apparel & Leather	0.94	0.93	0.93	0.92	0.92	0.93	0.92	0.94	0.94	0.92	0.95	0.94	0.95	0.95	0.95	0.93
Wood	0.96	0.96	0.96	0.94	0.91	0.85	0.83	0.83	0.86	0.87	0.89	0.88	0.93	0.94	0.95	0.94
Paper	0.75	0.69	0.72	0.78	0.8	0.73	0.73	0.72	0.73	0.78	0.81	0.77	0.82	0.81	0.81	0.81
Printing	0.98	0.96	0.96	0.94	0.93	0.93	0.90	0.90	0.86	0.86	0.91	0.93	0.92	0.90	0.89	0.88
Petroleum & Coal	0.94	0.94	0.93	0.88	0.93	0.94	0.95	0.91	0.92	0.86	0.74	0.85	0.81	0.61	0.51	0.46
Chemical	0.95	0.93	0.93	0.94	0.95	0.96	0.95	0.96	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96
Plastics & Rubber	0.89	0.88	0.90	0.93	0.94	0.92	0.93	0.92	0.9	0.91	0.92	0.92	0.93	0.92	0.91	0.88
Nonmetallic Mineral	0.93	0.88	0.91	0.92	0.92	0.91	0.90	0.93	0.93	0.91	0.92	0.93	0.92	0.92	0.9	0.88
Primary Metal	0.79	0.77	0.82	0.86	0.87	0.86	0.85	0.84	0.87	0.87	0.88	0.90	0.92	0.92	0.91	0.93
Fabricated Metal	0.96	0.95	0.95	0.95	0.96	0.96	0.95	0.94	0.94	0.94	0.96	0.95	0.96	0.95	0.95	0.95
Machinery	0.97	0.94	0.93	0.96	0.97	0.97	0.96	0.97	0.96	0.96	0.97	0.97	0.97	0.96	0.96	0.96
Computer & Electronic	0.91	0.92	0.93	0.93	0.95	0.96	0.95	0.96	0.97	0.98	0.98	0.95	0.91	0.95	0.95	0.96
Electrical Equipment	0.97	0.96	0.96	0.96	0.97	0.97	0.97	0.97	0.98	0.97	0.98	0.97	0.96	0.95	0.95	0.96
Transportation Equipment	0.94	0.92	0.92	0.94	0.95	0.95	0.94	0.94	0.94	0.96	0.97	0.95	0.95	0.95	0.95	0.95
Furniture & Related	0.95	0.93	0.94	0.94	0.95	0.96	0.95	0.95	0.95	0.95	0.96	0.96	0.96	0.95	0.95	0.95
Miscellaneous	0.95	0.95	0.96	0.96	0.94	0.94	0.93	0.94	0.95	0.92	0.94	0.94	0.96	0.95	0.95	0.94

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