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Productivity Growth in the Canadian Broadcasting and Telecommunications Industry: Evidence from Micro Data

by Wulong Gu and Amélie Lafrance

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^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

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Abstract

This study examines the dynamics of the rapid productivity growth that occurred in the Canadian broadcasting and telecommunications industry since the mid-1980s. Growth within firms was the main contributor to aggregate productivity growth. Both technical progress and scale economies contributed to aggregate productivity growth. During the 1984-to-1998 period, the competitive process associated with firm entry and exit made an important contribution to aggregate labour productivity growth. During the 2000-to-2008 period, firm entry and exit made little contribution to aggregate labour and multifactor productivity growth. Growth in aggregate labour productivity fell between these two periods, mainly because of a decline in the contribution of capital intensity, especially that from entry and exit.

Executive summary

The Canadian broadcasting and telecommunications industry experienced strong output growth after the mid-1980s. From 1984 to 2008, real gross output of this sector increased at an annual rate of 5.5%. The industry also had among the most rapid labour and multifactor productivity (MFP) growth rates during that period.

This paper examines two aspects of productivity growth in Canada's broadcasting and telecommunications industry. The first is the extent to which aggregate MFP growth in the sector came from scale economies as opposed to technical progress. The second is the extent to which aggregate labour productivity growth and MFP growth came from within-firm growth, and from the effect of reallocation due to firm entry and exit and within incumbents—the dynamic forces associated with competitive change.

Based on data from Statistics Canada's T2-LEAP longitudinal database, the analysis uncovers evidence of increasing returns to scale in broadcasting and telecommunications since 1984. Technical progress contributed between 1.3 and 1.4 percentage points to overall growth in aggregate MFP in the 1984-to-1998 and 2000-to-2008 periods, but scale economies were also important, accounting for about 0.5 percentage points, or 30% to 40%, of overall MFP growth in those two periods.

Growth within continuing firms was the most important factor in aggregate labour productivity growth and MFP growth. Firm entry and exit made an important contribution to aggregate labour productivity growth before 2000, but not thereafter. During the 1984-to-1998 period, when entrants had much higher labour productivity levels than did exits, firm entry and exit accounted for 1.2 percentage points, or about a quarter, of aggregate labour productivity growth. During the 2000-to-2008 period, firm entry and exit contributed 0.2 percentage points.

Annual aggregate MFP growth rose from 1.4% in the 1984-to-1998 period to 1.9% in the 2000-to-2008 period. The increase after 2000 was attributable to technical progress within firms, capacity utilization, between-firm reallocation, and net entry, each of which made a small but positive contribution.

Despite the increase in annual aggregate MFP growth after 2000, aggregate labour productivity growth slowed, mainly because of a decrease in the contribution of capital deepening, especially from firm entry and exit.

1 Introduction

The Canadian broadcasting and telecommunications industry experienced rapid output growth after the mid-1980s. From 1984 to 2008, real gross output in this industry increased at an average annual rate of 5.5%. As well, labour productivity (gross output per hour worked) rose by 3.9% per year, and multifactor productivity (MFP) by 1.2% per year[1]—rates that were among the highest of Canadian industries.

However, between the 1984-to-1998 and 2000-to-2008 periods, annual labour productivity growth in the industry slowed from 4.9% to 2.9%.

As well, productivity growth in Canadian broadcasting and telecommunications has been low compared with the United States (Baldwin and Gu, 2008). Since 2000, the industry has been one of the main contributors to lower overall productivity growth in the Canadian business sector relative to the U.S. The final report from the Telecommunications Policy Review Panel concluded that Canada's telecommunications industry is losing its competitive edge, particularly in the two most important and fastest-growing sectors: wireless and broadband services (Sinclair et al., 2006). Canada has the highest wireless voice and data rates among the OECD countries (Li and Nina-Moses, 2010), and is lagging behind Japan, South Korea and the U.S. in rolling out fiber optic cable and in the development of next-generation networks (Sinclair et al., 2006).

The lack of competition and the small scale of the industry in Canada have been cited as major factors in the lower productivity growth. Canada restricts foreign control of telecommunications providers (Sinclair et al., 2006), and the relatively small market compared with the U.S. may have a negative effect on the productivity of Canadian telecommunications, an industry where scale economies are important.

This paper quantifies the sources of aggregate productivity growth in Canadian broadcasting and telecommunications since the mid-1980s. Two questions are posed. First, to what extent did aggregate MFP growth in the industry come from scale economies rather than technical progress? Second, to what extent did aggregate labour productivity growth and MFP growth come from growth within firms and from reallocation due to firm entry and exit and shifts in share across incumbents—the dynamic forces associated with competitive change.

Measures of labour productivity and MFP are examined. Labour productivity indicates how efficiently labour is transformed in the production process. It is relevant because of its close connection with growth in real wage rates.

MFP is a more comprehensive weighted average of both labour and capital productivity. It is calculated as the difference between output growth and the growth in output that would be expected from the application of labour and capital inputs based on assumptions about production technology—that is, how much output additional units of labour and capital might be expected to have yielded. MFP is relevant because it is interpreted as capturing all unmeasured factors, including disembodied technical progress. More importantly, labour productivity growth can be decomposed into MFP growth and a term involving the growth in capital/labour intensity or capital deepening. Thus, underlying changes in the economy that affect labour productivity will be found in those that affect MFP growth and in those that affect changes in capital deepening.

The broadcasting and telecommunications industry in Canada consists of two sub-sectors: broadcasting (sub-sector 515 according to North American Industry classification System (NAICS), 2007) and telecommunications (NAICS 517). Telecommunications is dominant, accounting for more than 90% of total sales in the industry since 2000.[2] However, because of

1. Statistics Canada Productivity Program, CANSIM table 383-0022.
2. The share is calculated using the data from T2-LEAP. The data from the input/output tables showed a similar share.

growing integration of the two sub-sectors, it is difficult to classify firms into separate broadcasting or telecommunications categories. Therefore, this paper examines the combined broadcasting and telecommunications industry.[3]

Given that the industry is characterized by increasing returns to scale and imperfect competition, the growth accounting framework that was developed under the assumption of perfect competition and constant returns to scale is extended here to take those features into account (Solow 1957; Jorgenson and Griliches, 1967; Diewert 1976). The extended framework was developed by Denny et al. (1981), Diewert (1991), Hall (1988, 1990), Basu and Fernald (2001, 2002), Petrin and Levinsohn (2010), and Diewert et al. (2011).

Baldwin et al. (2012) adapted that framework for use with firm-level data and derived a method of decomposition that shows the extent to which the growth in aggregate labour productivity comes from a within-firm growth effect and from the effect of between-firm reallocation among incumbents and between entering and exiting firms. The within-firm growth component can be further decomposed into the effect of capital and intermediate input deepening, technological progress, scale economies, and input utilization. The between-firm component reflects the effect of reallocation of inputs and outputs across firms on aggregate capital and intermediate input deepening and aggregate MFP growth. Baldwin et al. (2012) also decomposed aggregate MFP growth into a within-firm growth effect that includes technological progress, scale economies and input utilization, and a between-firm reallocation effect that captures the effect of input reallocations across firms on aggregate MFP growth. Both decompositions are used here to examine whether the importance of the underlying components differs for each productivity measure.

The paper is organized as follows. Section 2 provides background information about the regulatory framework of Canadian broadcasting and telecommunications. It also summarizes previous studies of productivity growth in that sector. Section 3, borrowing heavily from Baldwin et al. (2012), describes the method used to examine productivity growth in the industry. Section 4 presents the data, and Section 5 describes the empirical evidence. Section 6 concludes.

2 An overview of the Canadian broadcasting and telecommunications sectors

The telecommunications industry consists of wired or wireline (the largest segment) and wireless telecommunications carriers, as well as satellite telecommunications. The broadcasting industry comprises radio and television broadcasting, and pay and specialty television. The penetration of telephone services in Canada is among the highest in the world; however, migration from traditional fixed-line to wireless services continues. Canada also has a high rate of broadband Internet access. While these potential opportunities have attracted entrants, both industries have barriers to entry. In broadcasting, the availability of licenses is limited, and telecommunications entry requires substantial capital outlay.

A number of studies have examined productivity growth in Canadian telecommunications. Denny et al. (1981) showed that, in the absence of perfect competition and constant returns to scale, MFP growth from the traditional accounting framework is no longer equal to technical progress. Rather, MFP growth is the sum of three components: technical progress, scale economies, and non-marginal cost-pricing that arises from regulation of the rate of return. When they applied that methodology to Bell Canada, the company's MFP was estimated to have increased 3.4% per

3. Investment and capital stock data are only available for the combined broadcasting and telecommunications industries. The output and intermediate inputs from the National Accounts are publicly available for the combined industries only.

year during the 1956-to-1976 period: 64% of the increase represented scale economies; 20%, the effect of technical progress; and 16%, the result of non-marginal cost pricing.

Other research has demonstrated the importance of scale economies. Fuss and Waverman (2002) concluded that most empirical studies on scale economies in the telecommunications industry report evidence of increasing returns. For example, a number of Canadian studies found that from the 1950s to the mid-1980s, the estimated returns to scale for Bell Canada ranged from 1.6 to 2.0.

Previous studies have also examined the multi-product nature of the telecommunications industry and the non-marginal cost pricing of outputs. When an industry produces multiple products, and because of regulation (rate-of-return or price-cap regulation), the price is not proportional to marginal costs, the correct weight to use to aggregate individual outputs is the share of cost elasticities, rather than revenue share, which would be appropriate in the case of perfect competition. Fuss (1994) found that for Bell Canada, the price was lower than marginal costs for local phone services, but higher for toll services. The bias introduced by using incorrect weights was found to be substantial in Bell Canada's case.

The telecommunications industry is capital intensive and entails considerable investment. The traditional growth accounting framework often requires the assumption of long-run equilibrium, with capital being fully adjusted to demand conditions. However, in the short run, capital is not fully adjusted, which may result in excess capacity. Because a direct observation of the rate of utilization of capital input is usually not available, earlier studies employed a proxy for capacity utilization to adjust the capital used in calculations of MFP growth.[4]

Berndt and Fuss (1982) developed a framework to take changes in capacity utilization into account. They argued that an adjustment should be made to the price of capital input in the traditional growth accounting framework. They showed that the ex post return on capital captures the effect of changes in capacity utilization. When the ex post return on capital is used to measure the contribution of capital to output growth, MFP growth calculated as the difference between output growth and the contributions of capital and other inputs is adjusted for changes in capacity utilization. Nonetheless, the procedure does not completely remove cyclical fluctuations in the MFP growth that are associated with variable capacity utilization (Basu and Fernard 2001, Hulten 2010).

Gu and Wang (2013) argued that the ex post return to capital should be used to adjust the quantity of capital input, not the price of capital input as in Berndt and Fuss (2012). They showed that when the ratio of ex post to ex ante return to capital is used to adjust the quantity of capital input, the measure of MFP growth takes the rate of capital utilization into account.

This paper examines scale economies, technological progress and capacity utilization in Canada's broadcasting and telecommunications industry. The analysis extends previous studies to examine the effect of the competitive process in the industry associated with the reallocation of inputs and outputs across incumbents and between entrants and exits. The paper does not examine the multi-product nature of and non-marginal cost pricing in broadcasting and telecommunications; such analysis requires information that is not available in the data used in this analysis.

4. Some studies provided direct evidence on the rate of capital utilization using survey data (the Institut national de la statistique et des études économiques (INSEE) has such survey).

3 Methodology

This section describes the methodology used to relate changes in aggregate labour productivity and MFP growth in broadcasting and telecommunications to what occurs at the firm level, following the approach of Baldwin et al. (2012).

Aggregate labour productivity and MFP growth can be decomposed into two main components: 1) within-firm growth and 2) between-firm reallocation arising from reallocation among incumbents and reallocation from firm entry and exit (Bartelsman et. al, 2005; Foster, Haltiwanger, and Krizan 2001; Griliches and Regev, 1995).

The decomposition method used by Baldwin et al. (2012) builds on work by Jorgenson (1966) and Jorgenson et al. (2005) that decomposes aggregate productivity growth into its industry components, but applies it at the level of the firm. It also introduces non-neoclassical features of the firm-level economic environment, such as imperfect competition and scale economies, whereas the original Jorgenson decomposition was developed under the assumption of perfect competition and constant returns to scale.

Jorgenson (1966) and Jorgenson et al. (2005) derived a decomposition of aggregate MFP growth into a within-industry contribution and a between-industry reallocation by comparing two approaches to estimating aggregate MFP growth: a production possibility frontier approach and a method that directly aggregates across industries, sometimes called the “top-down” and “bottom-up” approaches (Diewert and Yu, 2012; Gu, 2012; and Schreyer 2012). Unlike the original decomposition by Jorgensen (1966) and Jorgenson et al. (2005), which uses industry-level data, the present study uses firm-level data.[5]

3.1 Production possibility frontier approach

The production possibility frontier approach assumes that capital, labour and intermediate inputs receive the same price in all firms, but firms have different production functions that relate gross output (V) to capital, labour and intermediate inputs at the firm level, and the price of gross output differs across firms.[6] Under these assumptions, aggregate gross output can be expressed as a function of aggregate capital, aggregate labour, aggregate intermediate input, and a time variable that proxies technology (T), whereas the aggregate gross output can be written as a Tornqvist aggregation of gross output across firms:

$$V = F(K, L, M, T), \text{ and } \Delta \ln V = \sum_i \overline{w}_i \Delta \ln V_i, \quad (1)$$

where $\Delta \ln$ denotes the change between periods $t-1$ and t in logarithm, and $\overline{w}_i$ is the share of firm i in aggregate nominal gross output, averaged over the two periods.

5. Basu and Fernald (2002) and Petrin and Levinsohn (2010) proposed a similar decomposition. The contribution of the present study is to show that the decomposition is related to the work of Jorgenson (1966) and Jorgenson et al. (2005) who decomposed aggregate MFP growth into contributions of individual industries.
6. Firms will pay the same prices for intermediate inputs if they purchase the same mix of output from other firms for intermediate input use. The formulation in this section is similar under the alternative assumption that gross output function is the same across firms, and the prices of all inputs and output are the same across firms. This ensures the existence of aggregate gross output production function at the industry level.

Aggregate labour productivity growth, defined as the difference between growth in aggregate gross output and growth in aggregate labour input, can be written as:

$$\begin{aligned}\Delta \ln P &= \Delta \ln V - \Delta \ln L \\ &= \sum_i \overline{w}_i \Delta \ln P_i + \left(\sum_i \overline{w}_i \Delta \ln L_i - \Delta \ln L \right),\end{aligned} \tag{2}$$

where $\Delta \ln P_i = \Delta \ln V_i - \Delta \ln L_i$ is labour productivity growth at firm i, defined as the difference between output growth $\Delta \ln V_i$ and labour input growth $\Delta \ln L_i$. The growth in aggregate labour productivity in equation 2 is decomposed into two components: a within-firm effect, holding firms' shares constant, and a between-firm reallocation effect. The within-firm effect is positive when labour productivity increases within firms; the between-firm reallocation effect is positive when labour shifts toward firms with higher labour productivity.

When the product and factor markets are competitive and the production function is characterized by constant returns to scale, aggregate MFP growth can be expressed as the difference between aggregate labour productivity growth and the effect of capital and intermediate input deepening, using the standard growth accounting framework:

$$v_T = \Delta \ln P - \overline{\alpha}_K \Delta \ln(K / L) - \overline{\alpha}_M \Delta \ln(M / L), \tag{3}$$

where v_T is MFP growth, and $\overline{\alpha}_K$ and $\overline{\alpha}_M$ are the shares of capital and intermediate inputs in nominal gross output, averaged over the two periods.

Aggregate labour productivity growth, aggregate MFP growth and aggregate capital and intermediate input deepening effects from the top-down approach can be traced to what occurs at the firm level. This is done from direct aggregation across firms, as shown in the following section.

3.2 Direct aggregation across firms

The alternative approach for estimating aggregate labour productivity and MFP is direct aggregation across firms (Jorgenson et al 1987, 2005). This method relaxes the assumption in the production possibility frontier approach that all inputs receive the same price across all firms. Instead, it assumes that the prices of capital, labour and intermediate inputs differ across firms. For this analysis, the direct aggregation approach is extended to take into account non-neoclassical features of the economic environment in which firms operate. Specifically, it is assumed that the production function of individual firms is characterized by increasing returns to scale, and that there is imperfect competition in the product market.

Firm i is assumed to have a production function that expresses gross output (V_i) as a function of capital (K_i), labour (L_i), intermediate inputs (M_i) and technology (T_i):

$$V_i = F^i(e_{Ki} K_i, e_{Li} L_i, e_{Mi} M_i, T_i), \tag{4}$$

where e_{Ki}, e_{Li}, e_{Mi} denote the unobserved utilization of capital, labour and intermediate inputs, and T_i indexes technology. The production function exhibits increasing returns to scale γ_i.

Following Hall (1990) and Basu and Fernald (2001, 2002), output growth can be written as[7]:

$$\Delta \ln V_i = \mu_i \Delta \ln X_i + a_i \Delta \ln e_i + v_{T,i}, \tag{5}$$

where $\Delta \ln X_i$ is a weighted sum of input growth using the share of input costs in nominal gross output as weights:

$$\Delta \ln X_i = (\bar{\alpha}_{Ki} \Delta \ln K_i + \bar{\alpha}_{Li} \Delta \ln L_i + \bar{\alpha}_{Mi} \Delta \ln M_i), \tag{6}$$

and $\Delta \ln e_i$ is a weighted sum of the changes in input utilization:

$$\Delta \ln e_i = \bar{\alpha}_{Ki} \Delta \ln e_{Ki} + \bar{\alpha}_{Li} \Delta \ln e_{Li} + \bar{\alpha}_{Mi} \Delta \ln e_{Mi}. \tag{7}$$

$\bar{\alpha}_{Ki}$, $\bar{\alpha}_{Li}$, and $\bar{\alpha}_{Mi}$ are the average cost shares of capital, labour and intermediate inputs in nominal gross output. The sum of those input cost shares in gross output is less than one if there is economic profit. $v_{T,i}$ is MFP growth. μ_i is the mark-up over marginal cost. The mark-up is related to the returns to scale γ_i ,and the ratio of economic profits to total revenue $s_{\pi i}$, by the following equation:

$$\mu_i = \frac{P_i}{MC_i} = \frac{AC_i}{MC_i} \frac{P_i}{AC_i} = \gamma_i / (1 - s_{\pi i}). \tag{8}$$

The first equality in equation (8) follows from the definition of mark-up as the ratio of output price (P_i) to marginal cost MC_i. The last equality follows from an implication of cost minimization. The ratio of average cost (AC_i) to marginal cost equals the extent of returns to scale (γ_i) under the assumption of cost minimization.

In the analysis that follows, economic profits will be assumed to be zero. This will be the case if the industry is characterized by monopolistic competition.[8] When economic profits are zero, mark-up is equal to returns to scale, and the sum of input costs' share in nominal gross output is equal to one. Subtracting labour input growth from both sides of equation (5) yields the following equation showing the source of growth in labour productivity at firm i:

$$\Delta \ln P_i = (\mu_i - 1)\Delta \ln X_i + \bar{\alpha}_{Ki} \Delta \ln(K_i / L_i) + \bar{\alpha}_{Mi} \Delta \ln(M_i / L_i) + a_i \Delta \ln e_i + v_{T,i}. \tag{9}$$

The equation decomposes growth in firm labour productivity into its various components, including scale economies, capital deepening, intermediate input deepening, variable input utilization, and technological progress.

7. It is assumed that mark-ups do not change over a period. When they do change, the average mark-up over the period should be used in the equation.
8. The decomposition can be extended to a more general framework when economic profits are not zero.

The growth in firm labour productivity can be aggregated using equation (2) to derive aggregate labour productivity growth, which is then substituted in equation (3) to obtain a decomposition of aggregate MFP growth:

$$\begin{aligned} v_T &= \sum_i \bar{w}_i(\mu_i - 1)\Delta \ln X_i + \sum_i \bar{w}_i a_i \Delta \ln e_i + \sum_i \bar{w}_i v_{T,i} + \sum_J REALL_J \\ REALL_J &= \bar{\alpha}_J \left(\sum_i \bar{w}_{Ji} \Delta \ln J_i - \Delta \ln J \right),\ w_{Ji} = \frac{P_{Ji} J_i}{P_J J},\ J = K, L, M \end{aligned} \qquad (10)$$

where $\bar{w}_{Ji}$ is the share of firm i in the cost of input J averaged over two periods; P_{Ji} is the price that input J receives at a firm; and P_J is the price of input J in the production possibility frontier approach.[9]

Aggregate MFP growth is decomposed into a within-firm growth component and a between-firm reallocation component. The within-firm component as shown in the first three terms captures the effect of changes at individual firms, holding their output share constant, that includes the effect of scale economies, variable input utilization, and technical progress. The last term of the decomposition is the between-firm component that measures the effect of reallocation of capital, labour and intermediate inputs on aggregate MFP growth. Reallocation of an input contributes positively to aggregate MFP growth if the input is shifted toward firms with a higher input price and a higher marginal product. Under the assumptions of constant returns to scale, perfect competition and no excess capacity, the MFP decomposition (10) simplifies to the more standard decomposition as shown in the last two terms that expresses aggregate MFP growth as a sum of within-firm and between-firm reallocation effects (Jorgenson, et al., 2005).

Aggregation of labour productivity growth given in equation (9) across firms using equation (2) yields a decomposition of aggregate labour productivity growth:

$$\Delta \ln P = \sum_i \bar{w}_i \Delta \ln P_i + \left(\sum_i \bar{w}_i \Delta \ln L_i - \Delta \ln L \right), \qquad (11)$$

where,

$$\begin{aligned} &\sum_i \bar{w}_i \Delta \ln P_i \\ &= \sum_i \bar{w}_i \left(\mu_i - 1 \right) \Delta \ln X_i + \sum_{J=K,M} \sum_i \bar{w}_i \bar{\alpha}_{Ji} \Delta \ln \left(J_i / L_i \right) + \sum_i \bar{w}_i a_i \Delta \ln e_i + \sum_i \bar{w}_i v_{T,i}, \end{aligned} \qquad (12)$$

$$\begin{aligned} &\left(\sum_i \bar{w}_i \Delta \ln L_i - \Delta \ln L \right) \\ &= \sum_{J=K,L,M} REALL_J + \sum_{J=K,M} \bar{\alpha}_J \left(\Delta \ln(J/L) - \sum_i \bar{w}_{Ji} \Delta \ln(J_i / L_i) \right) \end{aligned} \qquad (13)$$

Aggregate labour productivity growth is decomposed into a between-firm and a within-firm component in equation (11). The within-firm effect is further decomposed into a scale effect, a capital and intermediate input deepening effect, a variable input utilization effect, and technical progress, as shown in equation (12). The between-firm reallocation effect is decomposed into the

9. When firm output is based on gross output and aggregate output is a value-added concept, the correct weights for aggregating MFP growth across firms are Domar weights, which are equal to the ratio of firms' gross output to aggregate nominal value-added (Domar, 1961).

effect of the reallocation of inputs on aggregate MFP growth as shown in the first term of equation 13, and the effect of reallocation on aggregate capital deepening and aggregate intermediate input deepening as shown in the second term of equation 13.

To complete the decomposition, it can be shown that the aggregate capital and intermediate input deepening effect from the production possibility frontier approach can be decomposed into the effect of capital and intermediate input deepening at the firm level, and the effect of input reallocation across firms on the aggregate capital deepening effect.

The decomposition of aggregate MFP growth and aggregate labour productivity growth needs to be extended to estimate the impact of firm entry and exit. For entering firms, inputs and outputs are observed only at the end of the period; for exiting firms, inputs and outputs are observed only at the start of the period. As such, the growth rates of inputs, outputs and productivity over a period cannot be calculated for entrants and exits. For this reason, recent empirical studies often focused on continuing firms and ignored the effect of firm entry and exit (Basu and Fernald, 2002; Petrin and Levinsohn, 2010).

To extend the decomposition to estimate the effect of firm entry and exit, it is assumed that a hypothetical firm exists whose inputs and outputs at the start of the period are set equal to those of exits, and whose inputs and outputs at the end of the period are set equal to those of entrants at the end of the period. The contribution of firm entry and exit to aggregate MFP growth, labour productivity growth and capital deepening can be measured as the direct contribution of the hypothetical firm to the within-firm component in the decomposition. For example, the contribution of firm entry and exit to aggregate labour productivity is estimated as the difference between the average labour productivity of the entry cohort at the end of a period and that of the exit cohort at the start of the period, multiplied by their average shares in aggregate output. This approach to estimating the effect of firm entry and exit is consistent with that of Baldwin (1995), who argued that if entrants essentially displace exits, the effect of firm entry and exit should be evaluated by comparing entrants and exits.

4 Data

This paper examines labour productivity growth and MFP growth in the Canadian broadcasting and telecommunications industry from 1984 to 2008. The firm-level data are from Statistics Canada's T2-LEAP longitudinal database, which covers all incorporated firms with employees. It contains detailed information from firms' financial statements, including balance sheets and income statements, and a longitudinal firm identifier that can be used to examine firm entry and exit over time. The 1984 to 1998 data are from the T2-LEAP file, which is based on the 1980 Standard Industry Classification (SIC); the 1999 to 2008 data are from the T2-LEAP file, which is based on the 2007 North American Industry Classification System (NAICS). The broadcasting and telecommunications industry examined in this paper consists of telecommunication broadcasting (SIC 481), telecommunication carriers (SIC 482), and other communication industries (SIC 483) for 1984 to 1998; it consists of broadcasting (NAICS 515) and telecommunications (NAICS 517) for 1999 to 2008.

Data on gross output, and on capital, labour and intermediate inputs are required in current and constant dollars. Gross output in current dollars is measured by total sales. Gross input in current dollars is the sum of the costs of capital, labour and intermediate inputs. The cost of capital is measured as net income,[10] and the cost of labour is measured by total payroll. The cost of intermediate input is calculated residually as the difference between sales and the sum of net income and total payroll.

10. The variable is called net income for tax purposes in the 1984-to-1998 T2-LEAP file, and net non-farm income in the 1999-to-2008 T2-LEAP file.

Gross output in constant dollars is derived by deflating total sales by a gross output deflator at the industry level taken from Statistics Canada's Productivity Accounts (Baldwin et al. 2007).

Capital input in constant dollars is measured by total assets deflated by a capital stock deflator at the industry level from the Productivity Accounts.

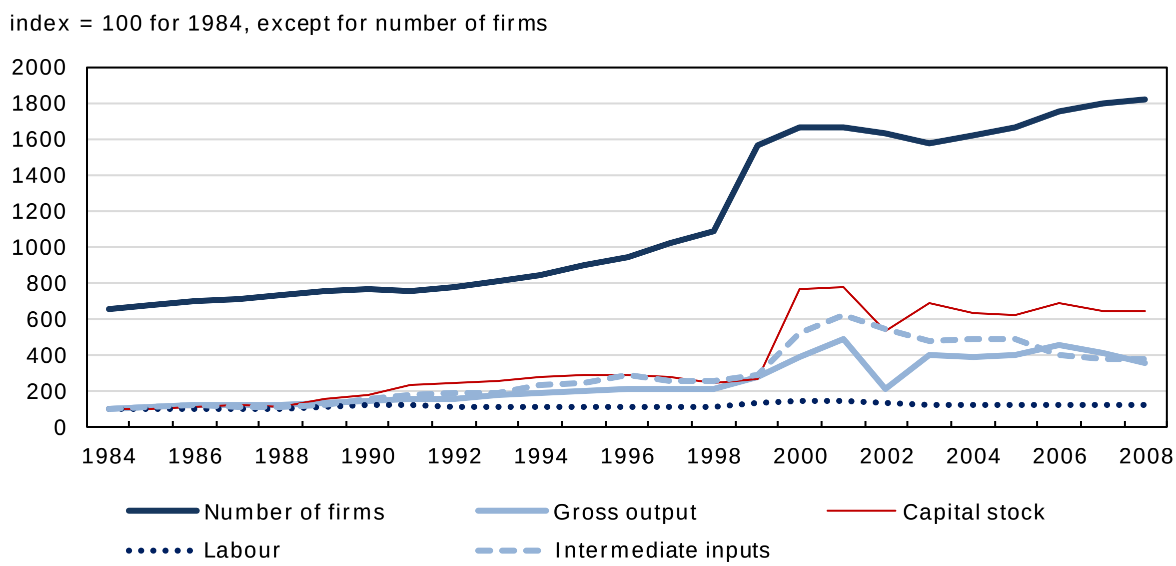
The cost of intermediate inputs in constant dollars is derived by deflating the cost of intermediate inputs by an intermediate input deflator at the industry level from the Productivity Accounts.

Labour input in T2-LEAP is measured by average labour units (ALU), calculated as the ratio of total payroll of a firm to the average annual wages of the workers in that firm's industry, size class and province.

Chart 1 displays the number of firms, output, and capital, labour and intermediate inputs from T2-LEAP for the broadcasting and telecommunications industry from 1984 through 2008. A break appears in the series from 1999 to 2000[11]. The data for 1999 from the NAICS T2-LEAP file are, therefore, not used. Instead, the analysis focuses on the 15-year period from 1984 to 1998 from the SIC T2-LEAP file, and the nine-year period from 2000 to 2008 from the NAICS T2-LEAP file.

Chart 1

Output, inputs and number of firms, broadcasting and telecommunications, 1984 to 2008



Notes: The data for 1984 to 1998 are from the T2-LEAP file (form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program) based on the Standard Industrial Classification for that period; the data for 1999 to 2008 are from the T2-LEAP file based on the North American Industry Classification System for that period.
Source: Statistics Canada, authors' tabulations from T2-LEAP.

Table 1 compares the annual growth rates of output, inputs and labour productivity in broadcasting and telecommunications estimated from T2-LEAP with the aggregate statistics from the Capital, Labour, Energy, Materials and Services (KLEMS) database[12]. For the 1984-to-1998 period, the two sources show similar growth rates in gross output, labour and labour productivity. In T2-LEAP, the growth of capital is somewhat higher, and the growth of intermediate input, somewhat lower. The differences in the growth rates of capital may reflect the differences in the

[11] This break is mainly due to a change in the source of the T2 data.
[12] The KLEMS database provides time series data for multifactor productivity, output and inputs including capital, labour, energy, materials and purchased services in the NAICS back to 1961.

valuation of capital in the two sources—capital in T2-LEAP represents the book value, whereas capital in the KLEMS database is valued at replacement costs.

Table 1

Annual growth rates of output and inputs, broadcasting and telecommunications, KLEMS versus T2-LEAP, 1984 to 1998 and 2000 to 2008

	1984 to 1998	2000 to 2008	2000 to 2008 less 1984 to 1998
		percent	
KLEMS			
Gross output	5.6	4.2	-1.4
Labour	1.2	1.4	0.2
Capital stock	4.3	0.1	-4.2
Intermediate input	7.8	4.6	-3.1
Labour productivity	4.4	2.8	-1.6
T2-LEAP			
Gross output	5.4	-1.3	-6.7
Labour	0.9	-1.6	-2.5
Capital stock	6.3	-2.1	-8.5
Intermediate input	6.8	-3.8	-10.6
Labour productivity	4.5	0.3	-4.2

Notes: Labour is measured by total hours worked in the KLEMS (Capital, Labour, Energy, Materials and Services) database, and by average labour units in T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program). Capital is measured by net capital stock in the KLEMS database, and by the book value of total assets deflated by capital stock price deflators in T2-LEAP.

Sources: Statistics Canada, authors' tabulations from KLEMS and T2-LEAP databases.

For the 2000-to-2008 period, the annual growth rates of output, inputs and labour productivity from T2-LEAP are generally lower than those from the KLEMS database. Both sources show declines in the growth rates of output, inputs and labour productivity, but the declines are more pronounced in T2-LEAP.

Table 2 compares output, capital, labour and intermediate inputs in nominal values estimated from T2-LEAP with the aggregate statistics from the KLEMS database. The share of labour cost in gross output is similar in the two sources—30% of gross output during the 1984-to-1998 period, and 20% to 25% during the 2000-to-2008 period. The share of capital cost in gross output is lower in T2-LEAP (about 20%) than in the KLEMS (about 40%), mainly because the capital cost in T2-LEAP excludes the amortization of tangible assets, whereas it is included in the KLEMS.[13] The share of intermediate inputs is much higher in T2-LEAP than in the KLEMS, because the cost of intermediate inputs is calculated residually in T2-LEAP.

13. Amortization of tangible assets is available, but often missing, on the NAICS T2-LEAP file for 1999 to 2008, and it is not on the SIC T2-LEAP file for 1984 to 1998.

Table 2

Average shares of inputs in nominal gross output, broadcasting and telecommunications, KLEMS versus T2-LEAP, 1984 to 1998 and 2000 to 2008

	1984 to 1998	2000 to 2008
	percent	**percent**
KLEMS		
Labour cost	30	25
Capital cost	43	37
Intermediate input costs	27	38
T2-LEAP		
Labour cost	30	20
Capital cost	17	18
Intermediate input costs	52	63

Notes: May not add up to 100% because of rounding. KLEMS stands for "Capital, Labour, Energy, Materials and Services"; T2 -LEAP stands for "Form T2 (Corporation Income Tax Return) linked to Employment Analysis Program".
Sources: Statistics Canada, authors' tabulations from KLEMS database and T2-LEAP. May not add up to 100% due to rounding.

For the decomposition, the T2-LEAP data are benchmarked to the aggregate data from the KLEMS database. This ensures that the book values of assets in T2-LEAP are adjusted to reflect the current costs of capital stock, and that the capital costs in T2-LEAP are adjusted to include the amortization of tangible assets, both of which are more appropriate for productivity analysis.[14]

Table 3 presents firm entry and exit rates in broadcasting and telecommunications for the two periods. For 1984 to 1998, entrants accounted for 74% of the total number of firms, and exits, 58%. The corresponding figures for 2000 to 2008 were 60% and 51%.

Table 3

Number, share of gross output and share of employment of entering, exiting and continuing firms, broadcasting and telecommunications, 1984 to 1998 and 2000 to 2008

	Firms	Share of of firms	Share of gross output	Share of employment
	number	**percent**		
1984 to 1998				
Entrants	691	74.4	24.3	17.0
Exits	330	58.1	4.9	7.8
Continuers	238	…	…	…
2000 to 2008				
Entrants	939	59.9	16.8	13.2
Exits	644	50.6	7.0	10.5
Continuers	628	…	…	…

… not applicable
Notes: Gross output and employment of continuers over a period are measured as the average of the start and end years' values.
Source: Statistics Canada, authors' tabulations from T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program).

14. Decomposition results using the original T2-LEAP data are similar, except for the relative importance of capital and intermediate input deepening for labour productivity growth. The capital deepening effect is lower and the intermediate input deepening effect is higher from the original T2-LEAP file, compared with those estimated from the benchmarked file. This is a result of relatively lower shares of capital costs and higher shares of intermediate input costs in the original file, which are used to estimate the capital and intermediate input deepening effects.

While entrants and exits made up a large share of the number of broadcasting and telecommunications firms, they accounted for small shares of gross output and employment.[15] For example, during the 1984-to-1998 period, entrants accounted for 24% of gross output and 17% of employment, and exiters, 5% and 8%, respectively.[16]

5 Empirical results

This section reports parameter estimates of scale economies and the effect of capacity utilization, which will be used to decompose aggregate productivity growth. It then presents the decomposition results for aggregate labour productivity growth and MFP growth for 1984 to 1998 and for 2000 to 2008.

Two approaches to estimating the scale economies and the effect of capacity utilization are discussed. The first estimates equation (5) that expresses log output growth as a function of log growth in combined inputs and a capacity utilization variable. The coefficient μ on the log growth in combined inputs provides an estimate of scale economies. The second approach estimates the reciprocal of the scale economies $1/\mu$ by estimating an equation that expresses the log growth in combined inputs as a function of log output growth and a capacity utilization variable:

$$\Delta \ln X_{it} = \alpha_o + \alpha \Delta \ln V_{it} + \beta \Delta \ln e_{it} + \varepsilon_{it}, \quad \alpha = 1/\mu, \ \varepsilon_{it} \text{ i.i.d. errors} \tag{14}$$

The scale economies term is just the reciprocal of the estimated coefficient $1/\alpha$, and the effect of capacity utilization on output growth is estimated as $-\beta/\alpha$.

Diewert and Fox (2008) considered these two approaches for estimating scale economies plus a number of others. Hall (1990) argued that if the prior expectation is that there are increasing scale economies, it is more informative to estimate the reciprocal of the scale economies and adopt the second approach, which Diewert and Fox (2008) considered to be more pragmatic.[17] This paper follows Hall and estimates equation (14) to obtain an estimate of scale economies.

The direct measure of capacity utilization is not available from T2-LEAP. The ratio of ex post return to capital to ex ante return to capital can be used as a measure of capacity utilization, but this requires an estimate of ex ante return to capital for each firm. This paper follows Baldwin et al. (2012) and uses the ratio of ex post capital income to gross output in logarithm as a measure of capacity utilization.

The sample for estimating the first difference equation (14) consists of a pooled sample of continuing firms over eight three-year periods: 1984-to-1987, 1987-to-1990, 1990-to-1993, 1994-to-1996, 1996-to-1998, 2000-to-2003, 2003-to-2006, and 2006-to-2008. The data for the first five periods are from the SIC T2-LEAP file; the data for the last three periods are from the NAICS T2-LEAP file. The results of using data for a pooled sample of continuers over periods of various lengths (such one, two, four or five years) are similar.

15. The firm entry and exit rates in terms of gross output and employment are higher here than those reported by Baldwin and Lafrance (2011), partly because of differences in the period examined. Moreover, imputations for sales and employment were made in the 2000-to-2007 T2-LEAP file, which was used in Baldwin and Lafrance (2011).
16. These firm entry and exit rates also suggest that entrants are more productive, and exits are less productive, than continuers in broadcasting and telecommunications. Furthermore, entrants are more productive and larger than exits. Similar evidence on the relative size and productivity of entrants, exits and continuers has been found in many other industries (Baldwin and Lafrance 2011).
17. Diewert and Fox (2008) also show that equation (14) is exact when there are multiple outputs and multiple inputs, and mark-up is equal across various outputs.

Firms with no sales and firms whose capital costs or intermediate input costs are zero or negative are excluded from the sample.[18] The estimates of the returns to scale and the effect of capacity utilization are presented in Table 4. A quantile regression is used in the first two columns to take potential outliers in the data into account. The ordinary least squares (OLS) results are reported in the last column for comparison.[19]

Table 4
Estimates of scale economies in broadcasting and telecommunications, 1984 to 2008

	Quantile regression		Quantile regression		Ordinary least squares (OLS)	
	Model 1		Model 2		Model 3	
	estimate	**p-value**	**estimate**	**p-value**	**estimate**	**p-value**
Alpha	0.801	0.006	0.8	0.006	0.835	0.022
Beta	...	...	-0.041	0.002	-0.05	0.004
Estimate of scale economies (1/Alpha)	1.25	...	1.25	...	1.2	...
Effect of capacity utilization (minus Beta/Alpha)	...	...	0.05	...	0.06	...

… not applicable
Note: All regressions include period fixed effects.
Source: Statistics Canada, authors' tabulations from T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program).

In broadcasting and telecommunications, the estimated return to scale from quantile regression is about 1.25, indicating, on average, increasing returns to scale. This is consistent with estimates for the industry reported in previous studies (Fuss and Waverman, 2002). The coefficient on the capital utilization variable has the expected sign and is statistically significant. The scale economies estimate from the OLS is slightly lower than the estimates from the quantile regression, signaling outliers in the sample.

For the decomposition of aggregate labour productivity growth and MFP growth, the estimates based on quantile regression in Column (2) are used, as they are robust to outliers. The decomposition uses the sample of all firms with positive sales, which includes firms with positive capital and intermediate input costs and those with negative capital and intermediate input costs.[20] As noted, some firms reported zero or negative capital and intermediate costs in T2-LEAP. Such firms accounted for about 10% of total sales in both the 1984-to-1998 and 2000-to-2008 periods.

Negative capital and intermediate inputs present an issue for aggregation across firms. In the decomposition framework presented above, the share of capital and intermediate input costs in total gross output is positively related to the marginal product of capital and intermediate inputs, which are all positive.[21] For firms with zero or negative capital and intermediate input costs, capital costs are set equal to the total assets of the firms times the industry average ratio of net income to total assets, and the intermediate input costs are set equal to nominal gross output of

18. About 10% of firm-year observations in the SIC T2-LEAP file report no sales for the 1984-to-1998 period; about 30% of firm-year observations report negative or zero intermediate inputs or negative or zero capital income, and those firms account for about 10% of total sales. Similar shares of firms with no sales, negative capital and intermediate input costs are found in the NAICS T2LEAP file for the 2000-to-2008 period.
19. The robust regression rreg in STATA programming software is also used, and the results are similar.
20. The results are similar when a subsample of firms with positive capital and intermediate input costs is used for the decomposition, except for the contribution of net entry to aggregate labour productivity growth. This suggests that firms with negative capital costs or negative intermediate inputs, including entrants and exits, are relatively small.
21. The share of capital and intermediate input costs in gross output is equal to the capital and intermediate input elasticity divided by the return to scale.

the firms times the industry average share of intermediate inputs in gross output.[22] Essentially, it is assumed that the user costs of firms with negative capital costs are the same as the average user costs of capital in the industry.

5.1 Results from the production possibility frontier approach

Table 5 presents the decomposition results for annual aggregate labour productivity growth in broadcasting and telecommunications from the production possibility frontier (top-down) approach. Aggregate labour productivity growth is decomposed into its main sources: aggregate capital and intermediate input deepening, and aggregate MFP growth.

Table 5

Decomposition of annual aggregate labour productivity growth, broadcasting and telecommunications, 1984 to 1998 and 2000 to 2008 (production possibility frontier approach)

	1984 to 1998	2000 to 2008	2000 to 2008 less 1984 to 1998
		percent	
Aggregate labour productivity growth	4.9	2.9	-2.1
Contribution from			
Capital deepening	1.4	-0.4	-1.8
Intermediate input deepening	2.1	1.3	-0.8
Multifactor productivity growth	1.4	1.9	0.5

Note: Percentages may not add up to rounding. Results are benchmarked to KLEMS (Capital, Labour, Energy, Materials and Services.

Source: Statistics Canada, authors' tabulations from T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program).

Aggregate labour productivity in broadcasting and telecommunications grew steadily since the mid-1980s, although the pace slowed from 4.9% per year in the 1984-to-1998 period to 2.9% in the 2000-to-2008 period, a 2.1-percentage-point decline. This slowdown was due to declines in capital deepening (investment) and in intermediate input deepening. The decline in capital deepening accounted for 1.8 percentage points of the overall decrease, and the decline in intermediate input deepening, 0.8 percentage points. By contrast, aggregate MFP growth rose from 1.4% per year in the 1984-to-1998 period to 1.9% per year in the 2000-to-2008 period.

5.2 Results from direct aggregation across firms

In the next three tables, annual aggregate labour productivity growth and MFP growth and the input deepening effects from the top-down approach are decomposed into a within-firm growth effect, a between-firm reallocation effect, and the effect of net firm entry. The within-firm component captures the effect of growth within continuers; the between-firm reallocation, the reallocation across continuers; and the net entry component, the direct contribution of entry and exit cohorts.

22. Alternatively, capital and intermediate input costs for firms with negative or zero capital and intermediate input costs can be imputed as sales times the industry average share of capital and intermediate input costs in total sales; the decomposition results of this imputation are similar. They can also be imputed using the ratios or shares in firms in the bottom quantile of the distribution. This is not expected to change the results, because firms with zero or negative capital and intermediate input costs account for a small share of gross output.

Table 6 presents a decomposition of aggregate labour productivity growth for 1984 to 1998 and for 2000 to 2008. Within-firm growth was the main contributor to overall labour productivity growth in both periods, accounting for 75% (3.6 percentage points) during the 1984-to-1998 period, and 95% (2.7 percentage points) during the 2000-to-2008 period.

Table 6

Decomposition of annual aggregate labour productivity growth, broadcasting and telecommunications, 1984 to 1998 and 2000 to 2008 (direct aggregation across firms)

	1984 to 1998	2000 to 2008	2000 to 2008 less 1984 to 1998
		percent	
Aggregate labour productivity growth	4.9	2.9	-2.1
Within-firm growth	3.6	2.7	-0.9
Multifactor productivity growth	1.3	1.4	0.1
Scale economies	0.5	0.6	0.0
Capital deepening	0.2	-0.2	-0.4
Intermediate input deepening	1.7	0.8	-0.9
Capacity utilization	-0.1	0.2	0.2
Between-firm reallocation	0.2	-0.1	-0.2
on multifactor productivity	-0.3	-0.3	0.1
on input deepening	0.5	0.2	-0.3
Net entry	1.2	0.2	-1.0

Note: Percentages may not add up due to rounding.
Sources: Statistics Canada, authors' tabulations from T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program).

The contribution of between-firm reallocation among incumbents was small: 0.2 and minus 0.1 percentage points in 1984 to 1998 and in 2000 to 2008, respectively.

Firm entry and exit made a substantial contribution to aggregate labour productivity growth before 2000 (1.2 percentage points or about a quarter of overall growth), but very little thereafter (0.2 percentage points). This is consistent with the results for entry and exit in Table 3—entering firms had much higher labour productivity levels than did exiting firms in the 1984-to-1998 period than they did in the 2000-to-2008 period.

Within-firm growth in labour productivity is a result of capital deepening (investment), intermediate input deepening, MFP growth, and scale economies. Change in capacity utilization also affects within-firm labour productivity growth.

The between-firm reallocation effect on aggregate labour productivity growth is the sum of the effect of reallocation on MFP growth and the effect on capital and intermediate input deepening. Reallocation had a small positive effect on input deepening, and a small negative effect on MFP growth.

The last column of Table 6 shows that two factors accounted for the drop in annual aggregate labour productivity growth between the two periods: a decline in growth within incumbents and a decline in the effect of net entry. The decline in labour productivity growth within incumbents accounted for 0.9 percentage points (40%) of the overall decrease, and the decline in the contribution of firm entry and exit, 1.0 percentage point (half).

The decline in labour productivity growth within incumbents resulted from a decline in capital and intermediate input deepening. There was little change in MFP growth and capacity utilization effects within incumbents.

Table 7 presents a decomposition of annual aggregate MFP growth for 1984 to 1998 and for 2000 to 2008. Within-firm growth was the predominant source of overall MFP growth in both periods. Between-firm reallocation and net firm entry made little contribution.

Table 7

Decomposition of annual aggregate multifactor productivity growth, broadcasting and telecommunications, 1984 to 1998 and 2000 to 2008 (direct aggregation across firms)

	1984 to 1998	2000 to 2008	2000 to 2008 less 1984 to 1998
		percent	
Aggregate multifactor productivity growth	1.4	1.9	0.5
Within-firm growth	1.7	2.1	0.4
Multifactor productivity growth	1.3	1.4	0.1
Scale economies	0.5	0.6	0.0
Capacity utilization	-0.1	0.2	0.2
Between-firm reallocation	-0.3	-0.3	0.1
Net entry	0.0	0.1	0.1

Source: Statistics Canada, authors' tabulations from T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program).

The within-firm component of aggregate MFP growth is the sum of MFP growth, scale economies, and capacity utilization. In both periods, MFP growth within incumbents (commonly associated with technical progress) was the most important source of aggregate MFP growth, contributing 1.3 and 1.4 percentage points. Scale economies were also important, contributing about 0.5 percentage points in both periods. By contrast, the effect of capacity utilization was small.

Between-firm reallocation had a negative effect, reducing aggregate MFP growth by 0.3 percentage points in both periods. The effect of reallocation on aggregate MFP growth is the sum of the reallocation effects of capital, labour and intermediate inputs. The magnitude of reallocation effects is driven by differences in the price of inputs across firms. Because the price of intermediate inputs is assumed to be equal across firms and is set equal to industry deflators, the reallocation effect of intermediate inputs on aggregate MFP growth is close to zero. And because the wage rates of labour in T2-LEAP differ only by firm size and province, the effect of reallocation of labour is also small. The reallocation effect on aggregate MFP growth was almost entirely due to reallocation of capital across firms, which made a small, negative contribution, indicating a shift of capital toward firms with lower user costs of capital.

Firm entry and exit made little contribution to aggregate MFP growth in both periods, but, as noted, made a substantial contribution to labour productivity growth in the 1984-to-1998 period. This suggests that the contribution of net entry to aggregate labour productivity in that period was entirely due to the higher input intensity of entering firms compared with exiting firms; there was little difference in MFP levels between entrants and exits in that period.

Aggregate MFP growth from the top-down approach rose from 1.4% per year in the 1984-to-1998 period to 1.9% in the 2000-to-2008 period. The last column of Table 7 shows the sources of this increase: technical progress, capacity utilization, between-firm reallocation, and net entry, each of which made a small but positive contribution.

Table 8 presents a decomposition of the contribution of aggregate input deepening to annual aggregate labour productivity growth. The aggregate input deepening effect is the sum of the effect of input deepening within incumbents, the effect of firm entry and exit, and the effect of reallocation across incumbents.

Table 8

Decomposition of aggregate input deepening effects on annual aggregate labour productivity, broadcasting and telecommunications, 1984 to 1998 and 2000 to 2008 (direct aggregation across firms)

	1984 to 1998	2000 to 2008	2000 to 2008 less 1984 to 1998
		percent	
Aggregate capital deepening effect	1.4	-0.4	-1.8
Contributions from			
Within-firm growth	0.2	-0.2	-0.4
Reallocation	0.4	-0.1	-0.5
Net entry	0.7	-0.1	-0.9
Aggregate intermediate deepening	2.1	1.3	-0.8
Contributions from			
Within-firm growth	1.7	0.8	-0.9
Reallocation	0.1	0.3	0.3
Net entry	0.4	0.2	-0.2

Source: Statistics Canada, authors' tabulations from T2-LEAP (Form T2 (*Corporation Income Tax Return*) linked to Longitudinal Employment Analysis Program).

The capital deepening effect, or the contribution of investment to aggregate labour productivity growth, was 1.4% per year over the 1984-to-1998 period. Firm entry and exit contributed 0.7 percentage points, because entrants were more capital intensive than exits. Capital deepening at the incumbent level contributed 0.4 percentage points, and reallocation, the remaining 0.2 percentage points.

For the 2000-to-2008 period, capital deepening made a negative 0.4 percentage-point contribution to aggregate labour productivity growth, reflecting negative contributions at the incumbent level and from reallocation and net firm entry.

The contribution of capital deepening to annual aggregate labour productivity growth fell by 1.8 percentage points between the 1984-to-1998 and 2000-to-2008 periods, mainly because of a reduction in the contribution from net firm entry. In the 1984-to-1998 period, net entry contributed positively to aggregate capital intensity, because entering firms were more capital intensive than exiting firms, but in the 2000-to-2008 period, net entry had little effect, as entrants and exits had similar capital intensity. Declines in the capital deepening effects within incumbents and between-firm reallocation also contributed to the decline in the overall capital deepening effect.

While the overall capital deepening effect is the outcome of its three components (within-firm growth, between-firm reallocation, and net entry), the overall intermediate input deepening effect is predominantly attributable to within-firm growth in intermediate input intensity. This is because of the assumption adopted in the paper that intermediate input deflators are equal across firms. While reallocation is less important, its magnitude is still larger than for MFP growth.

6 Conclusions

This paper examines two aspects of productivity growth in Canada's broadcasting and telecommunications industry. The first is the extent to which aggregate MFP growth in the sector is estimated to have come from scale economies as opposed to technical progress. The second is the extent to which aggregate labour productivity growth and MFP growth came from within-firm growth and from the effect of reallocation within incumbents and stemming from firm entry and exit.

The results show increasing returns to scale in broadcasting and telecommunications since 1984. While technical progress was the most important contributor to overall MFP growth, accounting for 1.3 to 1.4 percentage points annually, scale economies also made a significant contribution of about 0.5 percentage points, or 30% to 40% of the total.

Growth within continuers was the most important contributor to aggregate labour productivity growth and MFP growth. However, the importance of between-firm reallocation arising from incumbents and from net entry changed over time. The competitive process associated with firm entry and exit accounted for 1.2 percentage points, or about a quarter, of overall labour productivity growth in the 1984-to-1998 period, when entrants had much higher labour productivity levels than did exits. For the 2000-to-2008 period, entry and exit contributed 0.2 percentage points of labour productivity growth.

Aggregate MFP growth in broadcasting and telecommunications rose from 1.4% per year during the 1984-to-1998 period to 1.9% during the 2000-to-2008 period. The increase after 2000 was attributable to technical progress within firms, capacity utilization, between-firm reallocation, and net firm entry, each of which made a small but positive contribution.

Despite the increase in aggregate MFP growth, aggregate labour productivity growth in broadcasting and telecommunications slowed, mainly because of the decline in the contribution of capital intensity, especially from firm entry and exit. In the 1984-to-1998 period, net entry contributed positively to aggregate capital intensity, as entrants were more capital intensive than exits. A large number of firms took advantage of investment opportunities and entered the industry during that period. For the 2000-to-2008 period, net entry had little effect on aggregate capital intensity, as entrants and exits were similar in terms of capital intensity. Capital intensity also declined among continuers in this period, furthering the overall drop in the contribution of investment to aggregate labour productivity growth.

Labour productivity growth comes from within-firm growth and from reallocation both across incumbent firms and entrants and exits—though the former are more important. The within-firm component is due to MFP growth, exploitation of scale economies, and capital deepening. Changes in capital deepening come from within firms and from firm entry and exit. More important, the post-2000 slowdown reflects lower firm turnover associated with entry and exit, and less capital deepening, but not lower MFP growth. The meaning of these findings depends on how multifactor growth is interpreted. If MFP growth is interpreted as measuring disembodied technological change, then the two decades saw relatively constant technological change, but slowing capital intensity. If MFP is interpreted as capturing technological change, the slowing of capital intensity is related to how technology is introduced into the production process—through the acquisition of machinery and equipment and structures. Embodied technical change is driven by the acquisition of capital—and this decreased over the period. Of course, MFP measures encompass more than technological change; they include factors like the impact of infrastructure and intangible capital expenditures. Continued MFP growth after 2008 may be interpreted as indicating that no change has occurred in the factors underlying this statistic.

MFP growth over both periods was attributable less to turnover (either from incumbents or firm entry and exit) and more to growth within incumbents. This may indicate that the technological opportunities ostensibly captured by MFP are relatively ubiquitous across firms or that the simplifying assumptions in the estimation procedures about the similarity of prices do not allow reallocation effects to be measured with sufficient precision. It is, however, a result of this study that reallocation of resources is a substantial contributor to changes in capital intensity—and this is the primary way in which technology is introduced into the production process. Indeed, embodied technological progress is attained by increasing the amount of capital available per worker. This study indicates that competition in broadcasting and telecommunications was closely connected with this process.

The difference in the contribution of turnover in the industry to the disembodied technological progress encompassed by MFP growth and to the embodied technical progress encapsulated in changes in capital intensity is notable. However, this topic is beyond the scope of the present study, and the significance of these findings remains to be determined.

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