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Abstract

Many observers have rightfully expressed concerns about future prospects for Canada's economic growth and improvements in living standards, mainly because of Canada's lagging productivity level and/or growth relative to some Organisation for Economic Co-operation and Development (OECD) countries, and in particular to the U.S. Over the years, several potential factors have been put forward to explain Canada's weak productivity performance with respect to the U.S. Among them are the following three related factors: lower investment in fundamental innovation [as measured, e.g., by research and development (R&D) intensity], lower investment in applied innovation or the adoption and diffusion of new technologies [which are typically embodied in new machinery and equipment (M&E) - including information and communications technology (ICT) - capital], and the lack of competitive pressures (e.g., in product markets). Since competition is generally seen as the single leading catalyst for fundamental and applied innovation, this paper analyzes the role of product market competition in the Canada-U.S. productivity level gap. To this end, we develop an empirical framework in which competition exerts both direct and indirect effects on productivity, the latter through its impacts on fundamental and applied innovation. We find statistically significant evidence that the competition intensity differential (between Canada and the U.S.) has contributed to the Canada-U.S. productivity level gap directly, and indirectly through lower investments in both R&D activities and M&E (including ICT) capital. Overall, the discrepancy in competition intensity accounted for about 8.26% of the Canada-U.S. total factor productivity level gap over the 1987-2003 period in the business sector. We also find statistically significant evidence that Canada's relative poor performance in productivity and investments in technology adoption have acted as a self-reinforcing mechanism, which further causes detriment to the country's productivity.

Key words: competition, innovation (fundamental and applied), Canada-U.S. productivity gap

Résumé

Plusieurs observateurs ont exprimé avec raison des inquiétudes quant aux perspectives d'avenir de la croissance économique et de l'amélioration de la qualité de vie au Canada, surtout en raison de la faiblesse de la productivité canadienne et de sa croissance, par rapport à certains des pays de l'Organisation de coopération et de développement économiques (OCDE), en particulier les É.-U. Au fil des années, plusieurs facteurs potentiels ont été avancés pour expliquer la faible productivité canadienne en comparaison de celle des É.-U. Les trois facteurs suivants, qui sont interreliés, en font partie : investissement inférieur dans la recherche pure (mesuré, par exemple, par l'intensité de la R-D), investissement inférieur dans la recherche appliquée ainsi que dans l'adoption et la diffusion de nouvelles technologies (traditionnellement représenté par le capital de machines et équipement [M et É] neufs, qui inclut les technologies de l'information et des télécommunications [TIC]) et le manque de pression concurrentielle (p. ex. dans le marché des produits). Puisque la concurrence est généralement considérée comme le principal catalyseur de la recherche (pure ou appliquée), l'étude analyse le rôle de la concurrence dans le marché des produits dans l'écart de productivité entre le Canada et les É.-U. Dans ce but, nous avons créé un cadre expérimental dans lequel la concurrence a des effets directs et indirects sur la productivité, les effets indirects étant évalués par leur impact sur la recherche. Il apparaît de façon statistiquement significative que la différence dans l'intensité de la concurrence (entre le Canada et les É.-U.) a contribué à l'écart de productivité directement et indirectement, par des investissements moindres à la fois dans les activités de R-D et dans le capital de M et É (TIC incluses). Dans l'ensemble, la différence dans l'intensité de la concurrence explique environ 8,26 % de l'écart de productivité Canada-É.-U. de 1987 à 2003. Des résultats statistiquement significatifs montrent également que la faible productivité canadienne et le manque d'investissement dans l'adoption de nouvelles technologies entraînent un cercle vicieux qui cause des dommages supplémentaires à la productivité du pays.

Mots clés : concurrence, innovation (fondamentale and appliquée), productivité, écart de productivité etnre le Canada et les États-Unis

1 Introduction

Many academics and policy makers have expressed concerns about future prospects for Canada's economic growth and improvements in living standards, mainly because of Canada's lagging productivity level and/or growth relative to several Organisation for Economic Co-operation and Development (OECD) countries, and in particular to the United States (U.S.). For example, the OECD's decomposition of 2004 gross domestic product (GDP) per capita indicates that labour productivity level gap accounted for the entire (17%) per-capita income gap between Canada and the U.S. – see Figure A1.[1]

Over the years, several potential factors have been put forward to explain Canada's weak productivity performance with respect to the U.S. Among them are the following related factors:

- Lower investment in innovation, as measured, e.g., by research and development (R&D) intensity – i.e. R&D as a proportion of GDP.
- Lower investment in the adoption and diffusion of leading technologies, particularly new information and communication technologies (ICTs)
- Lack of competitive pressures (e.g., in product markets)

The R&D intensity in Canada is low compared to the U.S. and some other G-7 countries (see Figures A2 and A3), and this is true even when accounting for differences in the sectoral structure. This under-investment in R&D has rightfully raised concerns as the recent growth models argue that R&D is one of the key drivers of productivity improvements. Moreover, Figure A4 shows that Canada trails behind the U.S. in technology adoption and use. According to Fuss and Waverman (2005:42), 56 percent of the 21 percent aggregate labour productivity level gap between Canada and the U.S. in 2003 can be attributed to lower use and adoption of ICTs by Canadian firms.[2] Consistent with these findings, a recent Industry Canada study by Rao *et al.* (2006) reports that the gap in machinery and equipment (M&E), including ICT capital, was the dominant reason for the Canada-U.S. total factor productivity (TFP) level gap over the 1987-2003 period in the business sector.[3]

Besides, competition is typically seen as factor that improves productivity directly by removing organizational slack, and indirectly by increasing the pressure for firms to

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[1] Many commentators argue somehow that it is less worrisome if the gap in GDP per capita stems from low labour utilisation rather than weaker productivity (which is the opposite for Canadian case), as productivity 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.

[2] Fuss and Waverman break down the 56 percent contribution for 2003 into 12 percent from capital deepening and 44 percent from ICT spillovers. Similar results were obtained for 2000, although the overall ICT contribution to the productivity gap that year was somewhat higher at 60 percent.

[3] Focusing on TFP is justified by the fact that its gap has been accounting for the bulk of the Canada-U.S. labour productivity level gap. For example, in 2004, the gap in capital-labour ratio explained directly about 10 percent of the business sector labour productivity gap, while the remaining 90 percent was due to the gap in TFP (Rao *et al.*, 2006).

innovate and adopt and use new productivity-enhancing technologies such as ICT.[4, 5] Competition induced productivity improvements from these direct and indirect channels are referred to as static and dynamic productivity gains, respectively. According to Conference Board of Canada (2004), competition is often less intense in Canada than in the U.S., particularly in service-producing industries that focus on the smaller Canadian market. In the same line, the Executive Opinion Survey of the World Economic Forum (WEF) shows that Canada lags far behind the U.S. in terms of competition intensity. This evidence coincides with the fact that Canadian companies' strategies and operations do not value innovations enough, relative to companies in other G-7 countries (see WEF, Global Competitiveness Report, 2004-2005).

In its nineteenth report (in 1999), entitled *Research Funding: Strengthening the Sources of Innovation*, the Canadian House of Commons Standing Committee on Industry stressed that competition is probably the single leading catalyst in all types of innovation and, unless it is present, R&D incentives will be of little consequence.

Therefore, the lack of competitive pressure may be one of the *root* factors behind Canada's weak productivity performance.

Against this background, this paper investigates the role of product market competition in the Canada-U.S. productivity level gap, using an empirical framework that allows competition to exert both a direct effect on productivity and an indirect effect through innovation and the adoption of leading technologies.

As mentioned earlier, a recent Industry Canada study by Rao *et al.* (2006) explores the factors that might help explain the Canada-U.S. TFP level gap. A shortcoming of this research is that the underlying model does not explicitly take into account the impact of competition intensity on rationalization, organizational, innovations, and hence on TFP. Although this might be due to the lack of appropriate data availability,[6] another important related shortcoming of that paper is that the estimation results are subject to the usual (but serious) endogeneity or reverse causality criticism. Indeed, they *ex-ante* assumed that the causality runs, e.g., from variations in M&E and R&D to variations in TFP and *not* the reverse. However, better performing firms (or industries) – those with higher productivity levels or growth – are more likely to innovate and devote more resources to innovations, i.e. to invest more in M&E and R&D. Cainelli *et al.* (2006), for example, provide strong evidence on the two-way relationship between innovations (as measured by both R&D

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[4] According to Schmidt (1997) and Aghion and Howitt (1998), the opening up of markets and increased competitive pressures – by raising the threat of losing market share *vis-à-vis* the new and more advanced competitors – motivate existing firms (incumbents) to innovate, adopt new technologies and upgrade their machinery.

[5] In the literature, the adoption and diffusion of new technologies is referred to as applied innovation and the technology invention or 'true' innovation (as measured, e.g., by R&D expenditures) is referred to as fundamental innovation. Thus, unless otherwise indicated, the world 'innovations', hereafter, means and refers to both types of innovation activities.

[6] In fact, this current project is undertaken with the great hope that MEPA ongoing work on benchmarking competition intensity across Canadian and U.S. industries will provide us with the necessary data. But !!!

spending and ICT investments) and economic performance (as measured by labour productivity). Their findings provide empirical support for the endogenous nature of innovations, where productivity and innovations act as a self-reinforcing mechanism. Furthermore, recent endogenous growth literature predicts that the innovative behavior of firms (industries or countries) varies with their distance to the technological frontier. This distance is often measured (at the industry level) as the difference in TFP between each country-industry and the technological leader (the corresponding country-industry with the highest level of TFP). Consequently, the results in Rao *et al.* (2006) should be seen as an association rather than a *causal* impact.

Addressing the endogeneity problem is important. In fact, it has been one of the main challenges in trying to identify the causal impact of competition on innovations and/or productivity. There may be reverse causality, with innovations, for example, affecting competitive conditions. More specifically, higher performing firms (in terms of innovation or productivity) are likely to gain market shares, thereby reducing competition. Also, there may be omitted factors that are correlated with competition, innovations and productivity.[7] Therefore, any empirical studies exploring these relationships should pay greater attention to this problem and find a way to address it. Otherwise, any results we find are likely to be biased toward finding a more negative relationship between competition and innovations or productivity.

To our knowledge, there has been no rigorous empirical study examining the links between competition, innovations and productivity (within the same model) in explaining the productivity dynamics in Canada and across Canada and the U.S. In this project, we aim to fill this gap.

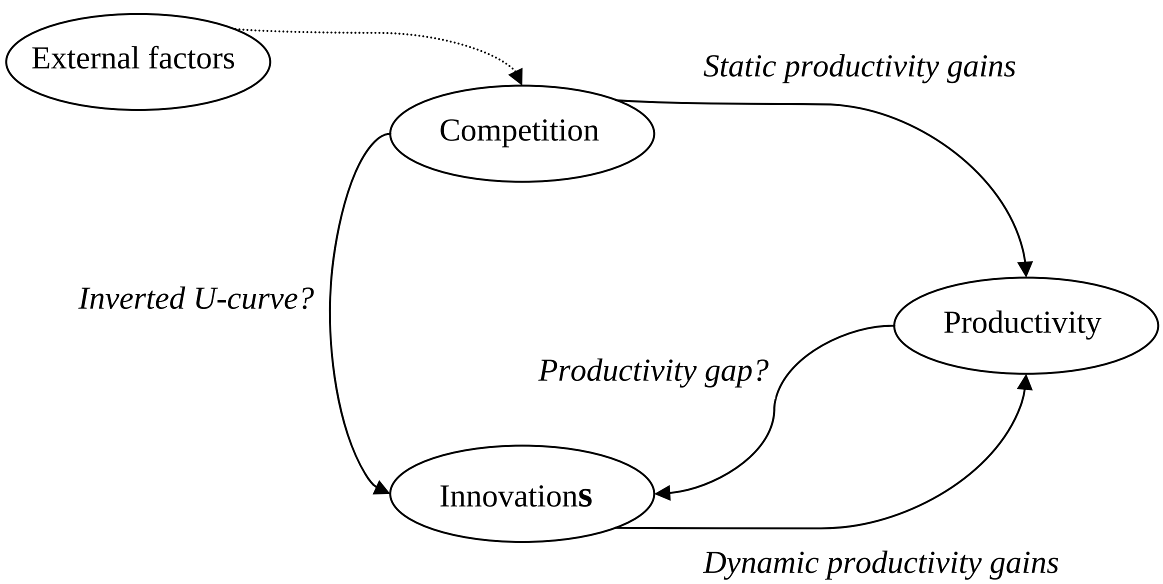
The remaining of the paper is organized as follows. In the next section, we provide a (theoretical) conceptual framework for the relationships between competition, innovations and productivity. Section 3 presents the empirical model. Section 4 provides a brief description of the dataset and the construction of the competition indicators, as well as our approach to purging the endogeneity in some of these indicators. Section 5 presents the empirical results of the econometric analysis, and finally section 6 concludes the paper.

[7] For example, market demand expansion might reduce competition pressure (initially) and eventually act as an important incentive (or stimulus) for both the entry of new firms (with more advanced technologies) and the incumbents' innovation investments and activities. Such other well known factors are, e.g., technological opportunity, natural endowments and location.

2 Theoretical Conceptual Framework

Figure 1 presents a theoretical framework for links between competition, innovations and productivity. First of all, as we are interested in identifying the *causal* impact of competition on innovations and productivity, it is assumed that external factors (such as policy changes that make entry into a market easier or less costly) lead to exogenous variation in the degree of competition. In assuming so, we can ignore the reverse causality from innovations or productivity to competition.[8]

Figure 1: Relationships between competition, innovations and productivity



As shown in Figure 1, increased competition may affect productivity in both direct and indirect ways, the latter channel through innovations (fundamental and applied). Competition induced productivity improvements from these direct and indirect channels are referred to as static and dynamic productivity gains, respectively.[9] More specifically, greater competition can improve productivity directly by leading to better resource allocation and by reducing organizational slack in the use of inputs, particularly managerial

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[8] Otherwise, while product market competition is likely to affect innovations, it is also the case that successful innovations affect market structure. Firms that are successful innovators will either have lower costs, and so will be able to sell at a lower price, or will have superior quality goods, and in either case will gain market share, thereby reducing competition. The same reasoning holds for high-productivity firms, as productivity is inversely related to marginal costs.

[9] The distinction between static and dynamic gains is employed mainly for the ease of presentation. In general, factors that imply one-time change in the level or growth of productivity (or output) are by definition static; but when transition processes involve changes in growth rates over longer periods, they are referred to as dynamic. Therefore, the distinction is not independent of the time horizon of the analysis.

slack under asymmetric information or moral hazard situations.[10] In the existing theoretical literature, there is little disagreement on the static productivity gains from stronger competition. However, the effect of increased competition on innovations (a channel through which it may indirectly lead to dynamic productivity gains) is less clear-cut, and has been quite controversial in the literature. For example, Aghion *et al*. (2005) have made some interesting contributions to this debate by showing that within the same model (and for different parameter values), increased competition may have a positive or negative effect on innovations, thereby on productivity.[11] In other words, they generate an inverted-U relationship between competition and innovations (as shown in Figure 1), which indicates that neither monopoly nor fully competitive market structures are the most conducive to innovations – an intermediate market structure generates the highest rate of innovation activities. Besides, Aghion *et al*. (2005) and Aghion *et al*. (2004a, 2004b) report that the impact of competition on a firm's (or industry's) innovation activities depends on its distance to the technological frontier. This distance is often measured as the difference in TFP between each firm/industry and the technological leader (i.e. the firm/industry with the highest level of TFP). This potential impact of productivity gap on (followers') innovations is depicted as well in Figure 1. For further details or for some other theories addressing the direct and/or indirect effects of competition on productivity, see Souare (2007a).

Overall, the impacts of competition on innovations and productivity are, at a theoretical level, ambiguous. For each channel (direct or indirect), there exist conflicting theories as whether greater competition increases productivity. In the end, the answer has to be found empirically.

3 The Empirical Model

In this section, we use a two-country empirical framework to develop three equations, one each for the Canada-U.S. TFP, fundamental and applied innovation level gaps across industries, respectively. Towards this goal, we assume (for each country-industry) that the intensity of competition influences productivity level both directly and indirectly, the latter through its impacts on innovations (fundamental and applied) – see the conceptual framework in Figure 1. Therefore, these equations can be estimated empirically to ascertain the relative importance of competition in explaining the Canada-U.S. productivity level gap. Next, we discuss in turn the equation for each gap.

Derivation of TFP level gap equation

Following the 'extended' endogenous growth models, we assume that total factor productivity (TFP) in each country-industry responds to changes in fundamental and

[10] Inefficiency or slack in the use of input is often referred to as 'X-inefficiency'.

[11] It is worth mentioning that since the role of innovation (fundamental and applied) as an engine of productivity improvements is both theoretically and empirically well established, we assume that the sign of the competition effect on productivity is determined by that of its impacts on innovations.

applied innovation, competition intensity, and other control variables. More formally, we have

$$TFP_{kit} = f_i(RD_{kit}, ME_{kit}, PMC_{kit}, X_{kit}), \quad k \in \{\text{Canada, U.S.}\}, \; i = 1,....n \qquad (1)$$

where RD represents the fundamental innovation (measured by R&D intensity, i.e. R&D as a proportion of GDP), ME denotes the applied innovation (measured by M&E, including ICT, capital-labour ratio), PMC is the product market competition indicator (whose computation will be discussed at length in the next section), X is a vector including other control variables (such as human capital, capacity utilization – business cycle), and the indices k, i and t denote countries, industries and years, respectively.

Taking the log-linear approximation of equation (1), we get

$$\ln TFP_{kit} = \lambda_{01} + \lambda_1 \ln RD_{kit} + \lambda_2 \ln ME_{kit} + \lambda_3 \ln PMC_{kit} + \lambda_4 \ln X_{kit} \qquad (2)$$[12]

Developing equation (2) for Canada and the U.S., and then taking the difference between these two equations gives

$$\ln \frac{TFP_{CA,i}}{TFP_{US,i}} = \alpha_0 + \alpha_1 \ln \frac{RD_{CA,i}}{RD_{US,i}} + \alpha_2 \ln \frac{ME_{CA,i}}{ME_{US,i}} + \alpha_3 \ln \frac{PMC_{CA,i}}{PMC_{US,i}} + \alpha_4 \ln \frac{X_{CA,i}}{X_{US,i}} \qquad (3)$$

Equation (3) represents the Canada-U.S. TFP level gap.

Derivation of innovations level gap equation

In this subsection, we develop the equation for the fundamental innovation gap and deduce the applied innovation one by similarity. As reported earlier, recent endogenous growth literature predicts, among others, that the innovative behavior of firms (industries or countries) varies with their distance to the technological frontier. Following the existing literature, we measure this distance as the difference in the (log) level of TFP in each country-industry relative to the technological frontier. Besides, in addition to competition, we also control for other factors most commonly used to explain fundamental innovation (such as human capital, capacity utilization) and applied innovation (such as capital and labour costs, human capital, capacity utilization).[13]

Thus, for Canada and the U.S, we express the fundamental innovation as follows

[12] In this equation (and in the subsequent ones), we assume parameter homogeneity across industries, countries, and time. Although somewhat restrictive, we had to impose this assumption given the relatively small number of observations for each country-industry. Nonetheless, it is a fairly acceptable assumption across the two countries under study. Besides, for the ease of exposition, we henceforth ignore the time subscript for all variables.

[13] Here, we overlook the fact that fundamental innovation (R&D spending) and applied innovation (investment in M&E) may affect each other.

$$\ln RD_{CA,i} = \gamma_{01} + \gamma_1 \ln \frac{TFP_{CA,i}}{TFP_{F,i}} + \gamma_2 \ln PMC_{CA,i} + \gamma_3 \ln Z_{CA,i} \tag{4}$$

$$\ln RD_{US,i} = \gamma_{02} + \gamma_1 \ln \frac{TFP_{US,i}}{TFP_{F,i}} + \gamma_2 \ln PMC_{US,i} + \gamma_3 \ln Z_{US,i} \tag{5}$$

where $TFP_{F,i}$ denotes TFP at the technological frontier and Z is a vector containing other control variables (such as human capital, capacity utilization). Taking the U.S. to be the technological frontier (i.e. $TFP_{F,i} = TFP_{US,i}$), the second term on the right-hand side of equation (5) disappears. Consequently, the difference between equations (4) and (5) is

$$\ln \frac{RD_{CA,i}}{RD_{US,i}} = \beta_0 + \beta_1 \ln \frac{TFP_{CA,i}}{TFP_{US,i}} + \beta_2 \ln \frac{PMC_{CA,i}}{PMC_{US,i}} + \beta_3 \ln \frac{Z_{CA,i}}{Z_{US,i}} \tag{6}$$

Equation (6) represents the Canada-U.S. fundamental innovation level gap.

Similar to equation (6), we can develop the following gap equation for applied innovation

$$\ln \frac{ME_{CA,i}}{ME_{US,i}} = \delta_0 + \delta_1 \ln \frac{TFP_{CA,i}}{TFP_{US,i}} + \delta_2 \ln \frac{PMC_{CA,i}}{PMC_{US,i}} + \delta_3 \ln \frac{W_{CA,i}}{W_{US,i}} \tag{7}$$

where W is a vector including other control variables, such capital and labour costs, human capital, capacity utilization (business cycle).

Therefore, using panel data on 36 industries (including goods and service producing industries) over the period 1987 to 2003, we estimate the following three equations – For industries covered, see Appendix B.

$$\ln \frac{TFP_{CA,i}}{TFP_{US,i}} = \alpha_0 + \alpha_1 \ln \frac{RD_{CA,i}}{RD_{US,i}} + \alpha_2 \ln \frac{ME_{CA,i}}{ME_{US,i}} + \alpha_3 \ln \frac{PMC_{CA,i}}{PMC_{US,i}} + \alpha_4 \ln \frac{X_{CA,i}}{X_{US,i}} + \mu_i + \varepsilon_{1i} \tag{3'}$$

$$\ln \frac{RD_{CA,i}}{RD_{US,i}} = \beta_0 + \beta_1 \ln \frac{TFP_{CA,i}}{TFP_{US,i}} + \beta_2 \ln \frac{PMC_{CA,i}}{PMC_{US,i}} + \beta_3 \ln \frac{Z_{CA,i}}{Z_{US,i}} + \mu_i + \varepsilon_{2i} \tag{6'}$$

$$\ln \frac{ME_{CA,i}}{ME_{US,i}} = \delta_0 + \delta_1 \ln \frac{TFP_{CA,i}}{TFP_{US,i}} + \delta_2 \ln \frac{PMC_{CA,i}}{PMC_{US,i}} + \delta_3 \ln \frac{W_{CA,i}}{W_{US,i}} + \mu_i + \varepsilon_{3i} \tag{7'}$$

where μ_i represents industry dummies and ε_s are the classical error terms.

Here, the key variable of interest is the competition variable, whose (gap) *causal* impact on the Canada-U.S. productivity level gap is being investigated. Towards this aim, the above general empirical model involves some appealing features. First, it allows assessing both the direct and indirect effects of competition intensity differential on the two-country relative productivity level, where the latter effect operates through both fundamental and applied innovation gaps. This modeling approach is closely in line with that undertaken in a European Commission study by Griffith *et al*. (2006a,b).[14] Second, it also addresses the endogeneity of productivity and innovations (gaps) with respect to each other. It is worth noting that this appealing feature is overlooked in Griffith *et al*. (2006a,b) – recall the earlier discussions on this issue. Nonetheless, a key issue that remains to be addressed is the possible endogeneity of competition indicator (although the inclusion of business cycle measure and industry dummies help, to some extent, alleviate this problem), and we will devote a substantial part of the next section to addressing this issue.

4 Data and the Construction of Competition Indicators

For our empirical analysis we use two different indicators of the strength of competition, namely: the OECD newly produced data of the 'knock-on' effects of anti-competitive regulations in non-manufacturing sectors on all sectors of the economy and our own constructed measure of the average profitability (or mark-up) whose potential endogeneity will need to be purged eventually. We now briefly discuss the construction of these indicators in turn.

The indicators produced by the OECD are also referred to as the regulation impact indicators, and a key ingredient in their construction is an indicator of regulatory conditions in seven non-manufacturing sectors: transport (airlines, railways, road freight), energy (gas, electricity), and communications (post, and telecoms). The coverage of regulatory areas varies across sectors and includes barriers to entry, public ownership, vertical integration, market structure, and price controls. The indicators for the seven non-manufacturing sectors have been estimated for 21 OECD countries over the period 1975 to 2003.[15] Combining these time series indicators with cross-section indicators of regulatory conditions in retail

[14] Griffith *et al*. (2006a,b) estimate three equations that investigate respectively the impact of regulatory reforms on product market competition (PMC), the effect of PMC on (fundamental) innovation, and the effects of both PMC and innovation on TFP growth. In order to address the potential endogeneity of the competition variable, as measured by average profitability or mark-up, they use reforms carried out under the EU Single Market Program to elicit exogenous variation in the degree of industry-wide competition, hence their first equation. Thereafter, the exogenously 'explained' competition – i.e. the fitted value – is used in the subsequent two equations as a measure of PCM. For further details on Griffith *et al*. (2006a,b) and some other empirical studies in this area, see Souare (2007a).

[15] According to Conway *et al*., 2006 (to which our brief description is indebted), although the resulting aggregate indicator misses important aspects of economy-wide regulation, it includes some of the sectors in which anti-competitive regulation is concentrated in OECD countries, given that manufacturing sectors are typically lightly regulated and open to international competition. In addition, this aggregate indicator is highly correlated with the cross-section indicator of economy-wide product market regulation in the years in which they overlap, suggesting that the former is a reasonable proxy for the latter.

distribution, banking, and business services, the OECD computed indicators of regulation impact for all sectors of the economy (i.e. 39 ISIC rev3 sectors) over the period 1975 to 2003 in 21 OECD countries.

According to the OECD, these regulation impact indicators are predicated on the notion that anti-competitive regulations in non-manufacturing sectors not only have a direct influence on market conditions in these sectors, but also have a less visible impact on the cost structures faced by firms that use the output of non-manufacturing sectors as intermediate inputs in the production process. This is especially the case given the large and increasingly important role of the non-manufacturing sector as a supplier of intermediate inputs in OECD countries over recent years. Thus, for each sector in a particular country the regulation impact indicator is calculated as a weighted average of the indicators of regulation in non-manufacturing sectors. The weights used in the calculation are total input coefficients, derived from (harmonised) input-output tables, which measure the extent to which intermediate inputs from each of the non-manufacturing sectors are used in the final output of each sector in the economy. Hence, the regulation impact indicators are a measure of the degree to which each sector in the economy is exposed to anti-competitive regulation in non-manufacturing sectors.[16]

However, Conway *et al*. (2006) argue that in addition to the intermediate inputs channel, the 'knock-on effects' of regulation in non-manufacturing sectors will also propagate through the economy via a number of other channels such as the effect on the price of investment goods and 'Baumol disease' effects that act through wages. As a result, focusing on the role of non-manufacturing sectors as suppliers of intermediate inputs provides only a lower bound to these propagation effects – although it does facilitate their empirical measurement, which is important for the empirical analysis. Therefore, partly because of this shortcoming,[17] we also construct an alternative measure (or a 'broader' indicator) of competition intensity, namely the average profitability or price-cost margin.

As discussed in Souare (2007a), the price-cost margin (PCM) or mark-up is not the only measure of competition in a market, but according to Boone (2000) it is more robust than many other commonly used measures, particularly those based on market shares and market concentration.[18]

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[16] The role of intersectoral input-output linkages in transmitting and amplifying the effects of product market reform has also been recently stressed by Faini *et al*. (2004). In Figure A5, we present the cross-country/industry patterns of the regulation impact indicators (for the latest available year, 2003). Here are some features to notice. First, the knock-on effect of anti-competitive regulation in non-manufacturing sectors is typically largest in ICT-using sectors. According to the OECD, this reflects the fact that these sectors tend to be more exposed to anti-competitive regulation in non-manufacturing sectors relative to other sectors. Second, regardless of the sector, the impact of regulation is high (i.e. more restrictive) in Canada than in the U.S., particularly in the ICT-using sector.

[17] It is worth mentioning that the potential bias that may result from this shortcoming (i.e. lower bound effects) would be alleviated (if not eliminated) in the present paper as we will be using the *relative* values of these indicators (across the two countries) in the empirical analysis.

[18] In addition to reviewing some (recent and influential) theoretical literature and empirical evidence on the impacts of (product market) competition on innovations and/or productivity, Souare (2007a) also neatly compares the pros and cons of the most widely used measures of competition.

We construct our industry-level measure of the mark-up (or PCM) as follows

$$PCM = \frac{ValueAdded}{LabourCosts + CapitalCosts}, \qquad (8)$$

where all variables are in nominal terms. This measure is equivalent to the price-cost margin under the assumption of constant returns to scale, such that marginal cost is equal to average cost. Thus, to the extent that there are increasing (decreasing) returns to scale this measure will be biased downwards (upwards) compared to the true mark-up.[19] The European Commission study by Griffith *et al*. (2006a,b) used the same expression, but did not provide the underlying micro foundations we just presented.

However, one shortcoming of the mark-up measure of competition is that in addition to product market competition, other factors (such as demand and cost shocks, technological opportunity) may affect the measure of the mark-up. To address any endogeneity of this type (and the one that arises from the mutual relationships between competition and innovations/productivity), we use 'policy' instruments – such as import tariffs and indicators of regulatory reforms – to isolate variation in the mark-up that is associated with changes in competition. More formally, we estimate the following equation

$$PCM_{kit} = g_i(PMR_{kit}, Tariffs_{kit}), \quad k \in \{\text{Canada, U.S.}\},\ i = 1,....n \qquad (9)$$

where PCM denotes price-cost margin (or mark-up), PMR represents product market regulation (i.e. the regulation impact indicator discussed above), and $Tariffs$ denotes

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[19] To illustrate this formally, consider the following production function $Q_{it} = A_{it} F_t(X_{it})$, where A_{it}, Q_{it}, and X_{it} represent respectively a productivity factor, output, and a vector of inputs for firm (or industry) *i* in year *t*. According to the basic producer theory, profit maximizing behavior requires that marginal costs be equal to the marginal revenue product. Assuming that the firm has some market power in the output markets and acts as a price taker in the inputs markets when determining its factor inputs, the first-order conditions (FOC) for profit maximization are $A_{it} \frac{\partial F_t(X_{it})}{\partial X_{it}^j} = \frac{W_{it}^j}{(1 - 1/\varepsilon_{it})P_{it}}$, where W_{it}^j is the factor price for input *j*, while the denominator on the right-hand side is marginal revenue with P_{it} and ε_{it} being the price of output and price elasticity of demand, respectively. According to the theory of imperfect competition, the factor $(1 - 1/\varepsilon_{it})^{-1}$ represents the markup (price over marginal cost), which we denote by PCM_{it}. Thus, the FOC can be rearranged as $\alpha_{it}^j = PCM_{it} \frac{W_{it}^j X_{it}^j}{P_{it} Q_{it}}$, where α_{it}^j is the output elasticity for factor *j*. Using this last expression and assuming that we have two factor (labour and capital) production function (in which case $j \in \{L, K\}$), it follows that $PCM_{it} = (\alpha_{it}^L + \alpha_{it}^K) \frac{P_{it} Q_{it}}{W_{it}^L X_{it}^L + W_{it}^K X_{it}^K}$, which is the 'true' expression for the markup or price-cost margin.

import tariffs.[20] Thus, this approach should help elicit exogenous variation in the degree of industry-wide competition (within each country) and enable us to identify the causal impact of competition on innovations and productivity.

Furthermore, to compute the cost of capital – for equation (8) – we use the long-term real interest rates plus capital depreciation rates. However, given the noticeable discrepancies in the rates of depreciation across Canadian and the U.S. industries (in the available data), we apply the U.S.-industry capital depreciation rates to both countries. The details on the construction of other variables are presented in the appendix B and most of them are indebted to Rao *et al.* (2006) who kindly provided these data.

Finally, it is worth mentioning that according to an OECD study (Bassanini and Ernst, 2002), a further advantage of relying on product market regulation indicators rather than the commonly used measures of competition is to mitigate endogeneity problems as well as issues related to the fact that usual measures (such as the price-cost margin or mark-up) are often non-monotonic in competition.

5 Empirical Results

Tables 1c-3c (in Appendix C) present regression results using the sample as described previously and where the competition intensity is measured by the extent of anti-competitive product market regulation (PMR). The estimation method we use is period SUR weighted least squares with panel-corrected standard errors (PCSE) due to period heteroskedasticity and serial correlation.[21] However, as the cross-section fixed effects cannot be used with period generalized least squares (GLS) weights, we classified industries into eight groups and assigned one dummy variable to each group. The eight industry groups are: construction (NAICS 23), resource-based manufacturing (NAICS 311, 312, 321, 322, 324, 326-332), labour-intensive manufacturing (NAICS 313-316, 337, 339), high-tech manufacturing (NAICS 323, 325, 333-336), trade (NAICS 41-45), utility, transportation and warehousing (NAICS 22, 48,49), information, FIRE and business services (NAICS 51-56), and other services (NAICS 61-81). The group dummy ($D_{i,j}$) equals one if $i \in j$ and zero otherwise.[22]

For the estimation results, consider first the Canada-U.S. relative TFP level equation (Table 1c). Our parameter estimates indicate that the competition intensity differential has a

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[20] We considered a general functional form for equation (9), as we intend to estimate both the linear and log-linear specifications, and retain the functional form that will give the best statistical fit.

[21] The advantage of this estimation method is that it corrects for both period heteroskedasticity and serial correlation without using the lagged dependant variable. A potential drawback of this method is that it may lead to overconfidence, particularly with small samples. However, the use of panel-corrected standard errors (PCSE) can overcome the potential overconfidence problem (Beck and Katz (1995)). Note that the period SUR specification is an example of what is sometimes referred to as the Parks estimator.

[22] Rao *et al*. (2006) use similar industry grouping.

positive and highly significant effect on the Canada-U.S. TFP level gap.[23] More precisely, the estimated coefficient implies that a one percent increase in the former would raise the latter by about 0.06 percent (other things being equal), and vice versa. In other words, this result means that the relative lack of competitive pressure in Canada has contributed directly to Canada's weak productivity performance with respect to the U.S. over the 1987-2003 period in the business sector.

Moreover, as would be expected, the gaps in M&E capital and R&D intensity, skills, and capacity utilization (the proxy for business cycle) have positive effects on the Canada-U.S. TPF gap over the same period, and all coefficients (except the one on skills) are highly statistically significant (at the 1% level). However, as we will see shortly, the lack of significance of the skill-gap coefficient could be due to the strong collinearity of skills with M&E capital and/or R&D intensity in our sample.

Next, consider the applied innovation (M&E capital) gap equation – Table 2c. Here as well, the estimation results indicate that there exists a positive and statistically significant relationship between the Canada-U.S. competition and M&E capital intensity gaps. The causal impact of the former on the latter gap implies an elasticity of 0.09. Consequently, as we have seen earlier (from Table 1c) that the gap in M&E capital contributed significantly to Canada's lagging productivity with respect to the U.S., the regression results in Table 2c provide evidence that the two-country competition intensity differential also contributed indirectly to Canada's relative poor productivity performance through the applied innovation or investments in technology adoption.

Besides, the regression results in Table 2c (combined with those in Table 1c) reveal a strong two-way relationship between the TFP level and M&E capital intensity gaps across the two countries. It seems that Canada's poor productivity performance has contributed *in turn* to its relative weak investments in technology adoption or M&E capital. The empirical findings in Table 2c show that the TFP gap term enters positively and its coefficient is highly significant, although (slightly) lower in magnitude compared to the impact of relative M&E capital intensity on TFP level gap (see Table 1c). This evidence on the reverse causality accords with the idea that better performing firms (or industries) – those with higher productivity levels or growth – are more likely to innovate and to devote more of their resources to innovations, i.e. to invest more in M&E, for example. Interestingly therefore, it appears that Canada's relative poor performance in productivity and M&E investment have acted as a self-reinforcing mechanism, which further causes detriment to the country's productivity.

Regarding other variables in Table 2c, the coefficient on the relative skills variable is positive and statistically significant at the 5% level. As mentioned previously, this complementary relationship between M&E capital and skills might explain in part the lack of significance of the skill coefficient in the TFP gap equation (see Table 1c), where both

[23] It is worth mentioning that the scale of the product market regulation (PMR) indicator is 0-1 from least to most restrictive. Therefore, a high value of this indicator reflects less competitive environment. Then, for ease of interpretation, competition intensity (within each country) is defined as the reciprocal of the PMR indicator, so that a high value indicates greater competition.

M&E capital intensity and skills are used among explanatory variables. The two-country relative factor costs – i.e. relative real wage rate and difference in real interest rates – have the expected positive and negative effects, respectively, on M&E capital intensity gap (although the coefficient on the difference in real interest rates is not statistically significant). Recall that M&E capital intensity is defined as the ratio of M&E capital to labour input. Therefore, these results are consistent with the fact that (if capital and labour are substitutable) an increase (decrease) in the cost ratio of capital to labour would likely result in lower (higher) capital intensity. Finally, the coefficient on business cycle (which is used as a proxy for capacity utilization) enters with a negative sign (as would be expected) and is statistically significant, reflecting the fact that the capital use adjusts less frequently than labour input due to business cycle. This implies that (M&E) capital intensity is counter-cyclical.

Now, consider the fundamental innovation (R&D spending) gap equation. The results reported in Table 3c show that the relative competition intensity has a positive and significant impact on the two-country R&D intensity gap. The elasticity of the R&D intensity gap with respect to the discrepancy in competition intensity is 0.42, implying that competition intensity differential has played a more important role in explaining the R&D intensity gap, compared to its contributions in TFP level and M&E capital intensity gaps (where its marginal impacts are about 0.06 and 0.09, respectively (see Tables 1c and 2c)). Thus, since the relative R&D intensity is a source of the TFP level gap (see Table 1c), it comes out that the gap in competition intensity has also contributed indirectly to Canada's lagging productivity (with respect to the U.S.) through the fundamental innovation or investments in technology invention (as proxied by R&D spending). Besides, in this R&D intensity gap equation, the relative TFP level does not have a significant impact (and enters with a counterintuitive sign). Further, as the competition intensity differential, the skills gap variable is found to have a positive and greatest marginal impact on the relative R&D intensity – compared to its (marginal) effects on both TFP and M&E capital intensity gaps (see Tables 1c and 2c, respectively). This implies that the technology invention (fundamental innovation) is more skill-biased than the technology adoption (applied innovation).

Finally, we attempt to ascertain (quantitatively) the relative economic importance of both the direct and indirect effects of competition intensity differential on the Canada-U.S. productivity level gap, with the latter effect operating through both applied and fundamental innovation. Towards this objective, we substitute out M&E capital and R&D intensity gaps (using their respective estimated equations) in the relative TFP level equation. Thus, using the resulting equation, we determine the contributions of the competition intensity gap to the Canada-U.S. productivity level gap. The results reported in Table 4c reveal that the discrepancy in the level of competition contributed to the two-country TFP level gap for about 6.33% directly, and about 0.42% and 1.50% indirectly through fundamental and applied innovation, respectively – i.e. via lower investments in R&D activities and the adoption of new technologies (which are typically embodied in new M&E capital). Overall, the discrepancy in the competition intensity accounted for about 8.3% of the Canada-U.S. TFP level gap over the 1987-2003 period in the business sector.

Next, we use expression (8) to compute an alternative measure of competition intensity, namely the price-cost margin or mark-up, whose potential endogeneity problem must be addressed. Therefore, we use indicators of anti (or pro)-competitive product market regulations (PMR) and import tariff rates as 'policy' instruments to provide exogenous variation in the mark-up measure that is associated with changes in competition intensity.[24] More specifically, we estimate equation (9) using both the linear and log-linear specifications. Although not reported here, the linear models (for both Canada and the U.S.) outperform the corresponding log-linear ones. Consequently, the results reported in Table 5c pertain to linear specifications. For Canada, the estimated coefficients on both the PMR and import tariff rates have the expected positive sign, and are highly statistically significant. The intuition runs as follows. Since the scale of the PMR indicator is 0-1 from least to most restrictive, an increase in this indicator (i.e. stronger regulations) implies weaker product market competition, which results in higher mark-ups. Similarly, an increase in import tariff rates involves restrictive competition to foreign producers, which also leads to higher mark-ups. Unfortunately however, the Canadian tariff rates appeared not to be such a good policy instrument to elicit induced exogenous competition, as their marginal effect is tiny and have little explanatory power – in fact, they account for only about 6% of the 38% adjusted R-squared. For the U.S. results, the situation is even worse as the coefficient on the tariff rates enters with a counterintuitive sign, although very small in magnitude.

Nonetheless, we computed the appropriate fitted values (i.e. policy instruments induced competition) from the regression results in Table 5c and referred to them as 'adjusted' price-cost margin or markup. Then, we re-estimated the equations for the TFP level, M&E capital and R&D intensity gaps with competition measured by the adjusted price-cost margin or mark-up (see Tables 6c-8c, respectively). Overall, the results point to either a mild or insignificant effect of competition intensity differential, compared to the corresponding results (in Tables 1c-3c, respectively) where the direct measure of the extent of pro-competitive PMR is used as a proxy for the strength of product market competition.

6 Conclusions

Many observers have rightfully expressed concerns about future prospects for Canada's economic growth and improvements in living standards, mainly because of Canada's lagging productivity level and/or growth relative to some OECD countries, and in particular to the U.S. Over the years, several explanatory factors have been put forward to explain Canada's weak productivity performance with respect to the U.S. Among them are the following three related factors: lower investment in fundamental innovation (as measured, e.g., by R&D intensity), lower investment in applied innovation or the adoption and diffusion of new technologies (which are typically embodied in new M&E -including ICT- capital), and the lack of competitive pressures (e.g., in product markets). Since competition is generally seen as the single leading catalyst for fundamental and applied

[24] Since we have used above the extent of anti-competitive PMR as a proxy for the strength of competition intensity, it should be stressed at the outset that the tariffs induced competition is what is expected to make this analysis relevant.

innovation, this paper analyzes the role of product market competition in the Canada-U.S. productivity level gap. To this end, we develop an empirical framework in which competition exerts both direct and indirect effects on productivity, the latter through its impacts on innovations (fundamental and applied).

Our main empirical findings sum up as follows. We find statistically significant evidence that the competition intensity differential (between Canada and the U.S.) has contributed to the Canada-U.S. productivity level gap directly, and indirectly through both fundamental and applied innovation gaps – i.e. via lower investments in both R&D activities and M&E (including ICT) capital, respectively. Overall, the discrepancy in the competition intensity accounted for about 8.3% of the Canada-U.S. TFP level gap over the 1987-2003 period in the business sector. We also find statistically significant evidence that Canada's relative poor performance in productivity and investment in technology adoption have acted as a self-reinforcing mechanism, which further causes detriment to the country's productivity.

Hence, an increase in the competition intensity in Canada (relative to the U.S.) would reduce the two-country productivity level gap directly, as well as indirectly by reducing the gaps in both fundamental and applied innovation – which are important determinants of the Canada-U.S. productivity gap.

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Appendix A

Figure A1: What's been driving the gap in per capita incomes?

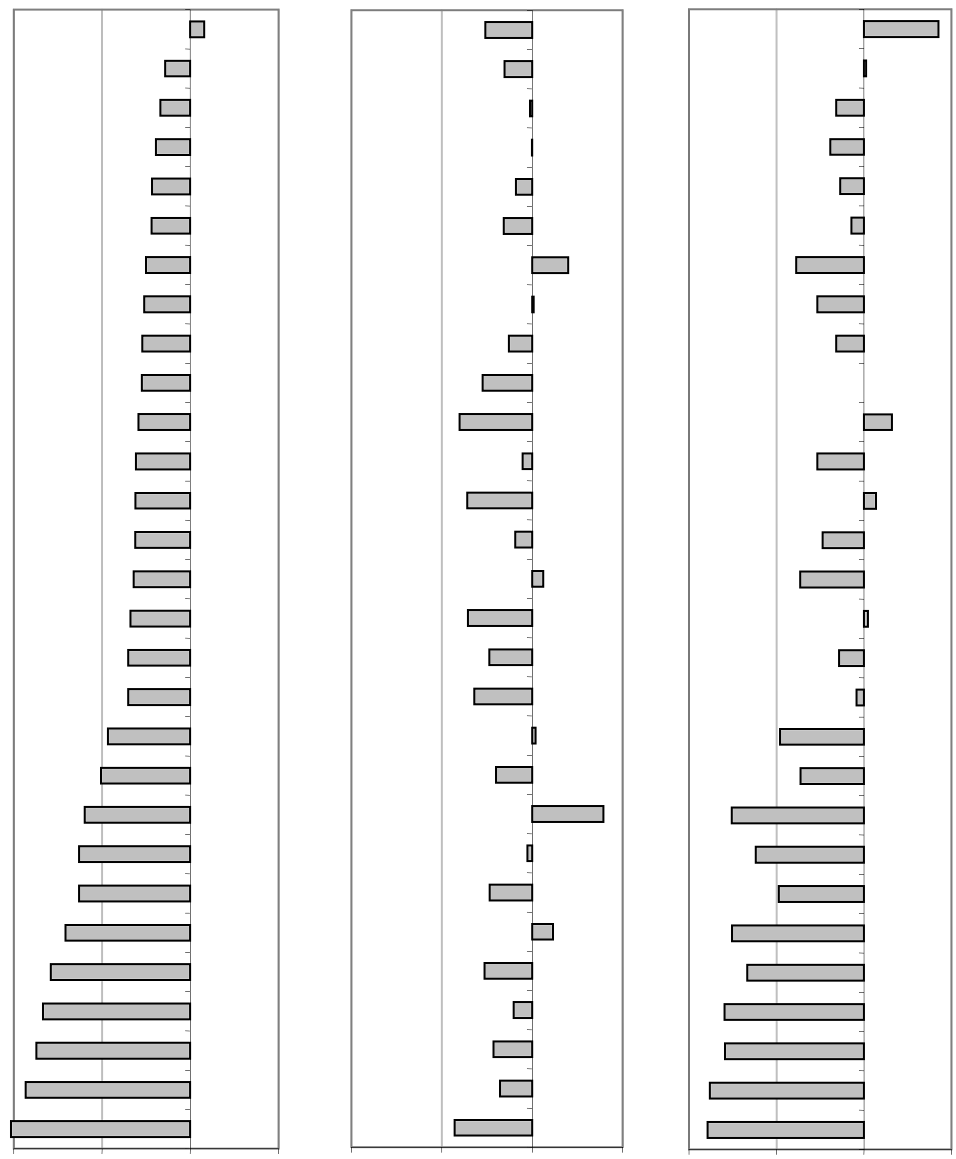


Figure A2: Business R&D intensity, average 2000-2004
(relative to average OECD R&D intensity)

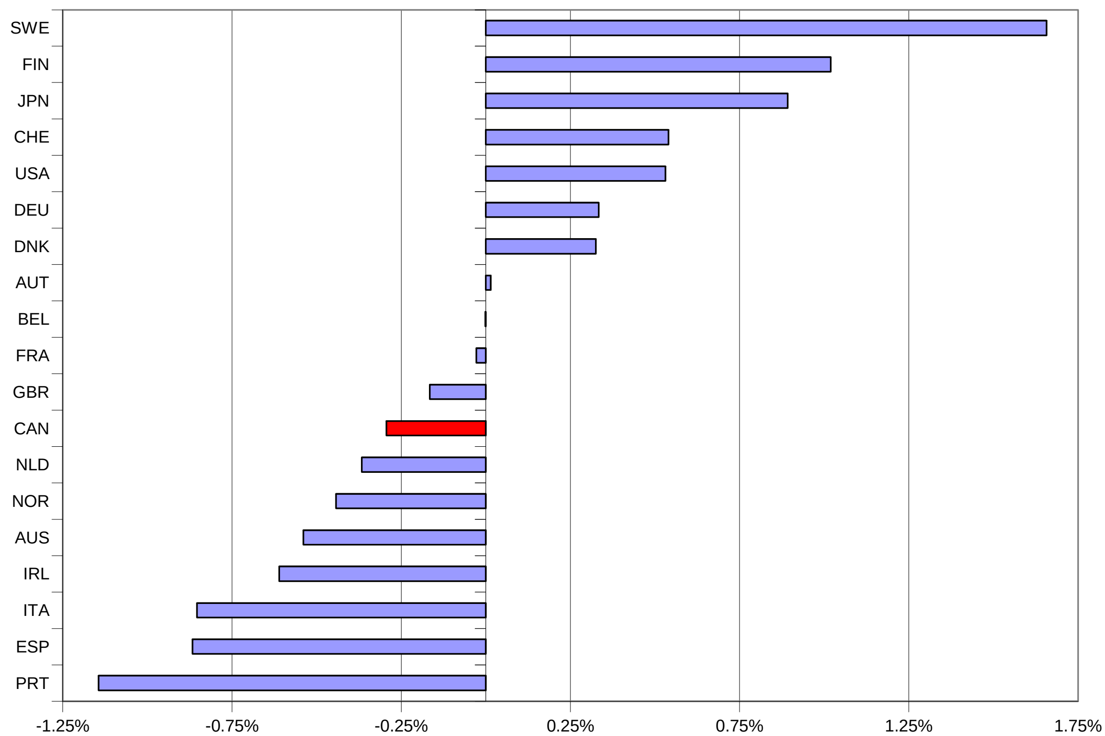
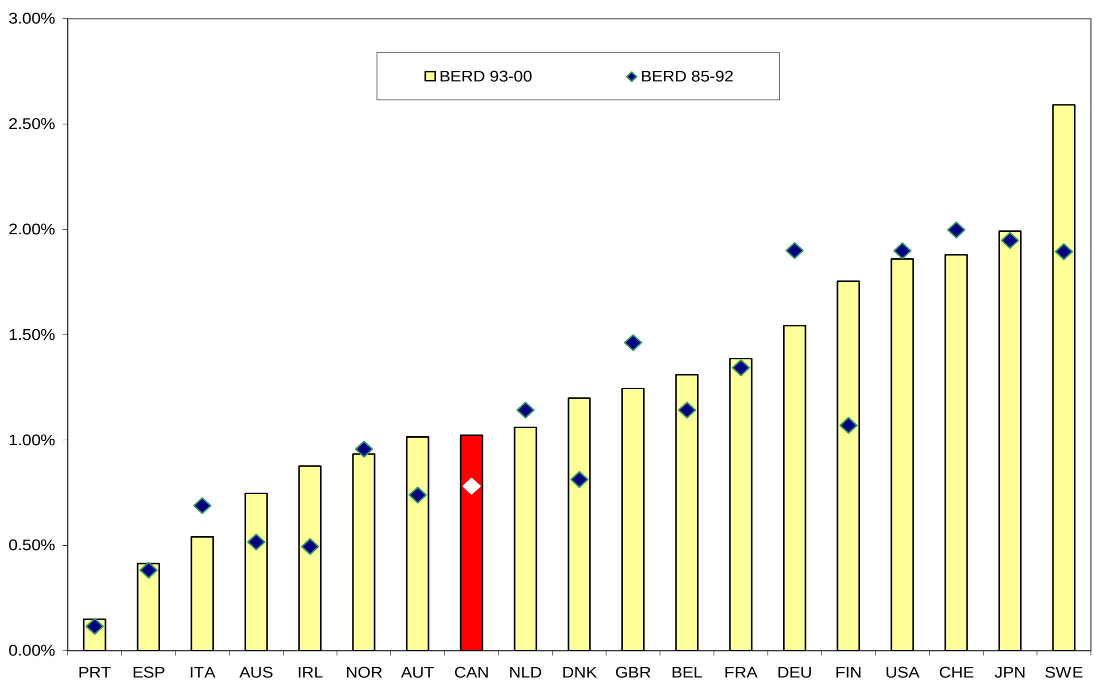
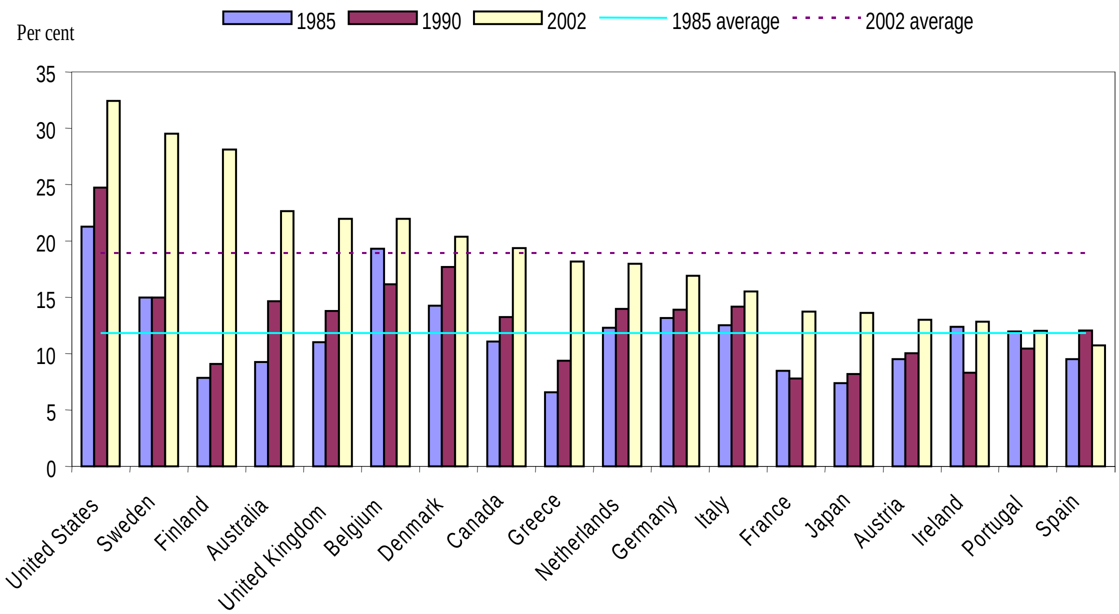


Figure A3: Average business R&D intensity, 1985-2000



Sources (**Fig. A2 and A3**): Our calculations based on OECD database

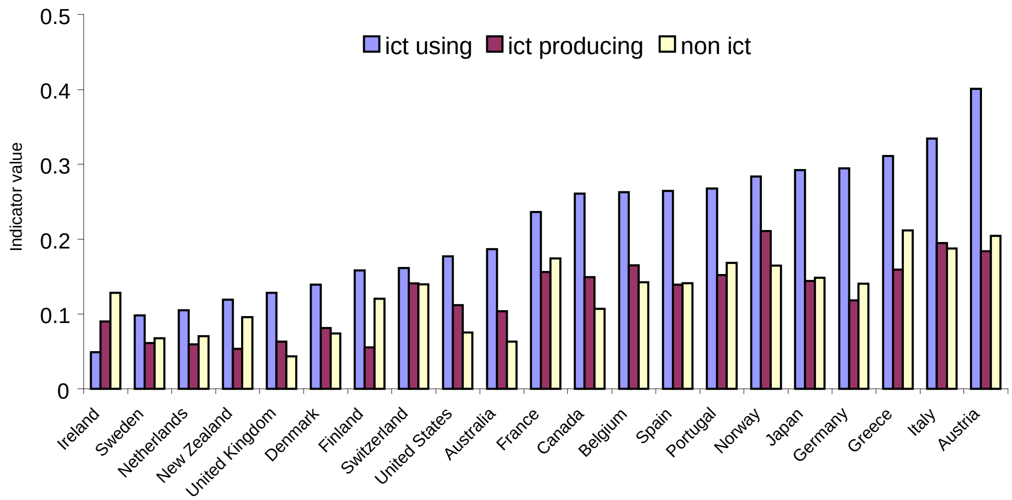
Figure A4: The diffusion of information and communication technologies
(share of ICT investment in total non-residential fixed capital formation)



Countries ordered according to ICT share in the most recent period.
Source: OECD, Database on capital services

Figure A5: The impact of regulation in ICT-producing, ICT-using, and non-ICT intensive sectors, 2003[1]

(The scale of the indicators is 0-1 from least to most restrictive)



1 These data are the simple averages of the 'regulation impact' indicators for the individual industries included in ICT-producing, ICT-using, and non-ICT intensive sectors in 2003. The classification of sectors as ICT-using, ICT-producing, and non-ICT intensive is provided below. The data is ordered according to the indicator values for ICT-using sectors.
Source: OECD international regulation database

ISIC code	*Industry*	*ICT classification*
15-16	Food Products, beverages and tobacco	N
17-19	Textiles, textiles products, leather & footwear	N
20	Wood except furniture	N
21-22	Pulp, Paper, paper products, printing & publishing	U
23-25	Chemical, rubber, plastics & fuel products	N
26	Other non-metallic mineral products	N
27-28	Basic metals and fabricated metal products	N
29	Machinery and equipment, n.e.c.	U
30-33	Electrical and optical equipment	P
34-35	Transport equipment	N
36-37	Furniture; recycling	U
40-41	Electricity, gas and water supply	N
45	Construction	N
50-52	Wholesale and retail trade; repairs	U
55	Hotels and restaurants	N
60-63	Transport and storage	N
64	Post and telecommunications	P
65-67	Financial intermediation	U
70	Real estate	N
71-74	Renting of M&EQ and other business activities	U

Notes: The classification of ISIC rev.3 sectors into ICT-producing (**P**), ICT-using (**U**), and non-ICT intensive (**N**) sectors used in this paper follows Inklaar, *et al.,* (2003).

Appendix B: Industries, Variable Definitions and Data Sources

INDUSTRY **Goods Producing Industries**	NAICS	**Service Producing Industries**	NAICS
Utilities	22	Wholesale trade	41
Construction	23	Retail trade	44, 45
Manufacturing		Railroad transportation	482
Food, beverage, tobacco	311, 312	Truck transportation	484
Textile	313, 314	Warehousing and storage	493
Apparel and leather	315, 316	Other trans. and warehousing	other 48, 49
Wood	321	Information and cultural industries	51
Paper	322	FIRE, management	52, 53, 55
Printing	323	Professional, scientific and technical serv.	54
Petroleum and coal	324	Administrative and support services	561
Chemical	325	Waste management and remediation serv.	562
Plastics and rubber	326	Educational services	61
Nonmetallic mineral	327	Health care and social assistance	62
Primary metals	331	Arts, entertainment and recreation	71
Fabricated metal	332	Accommodation and food services	72
Machinery	333	Other services (except pub. administration)	81
Computer and electronic	334		
Electrical equipment	335		
Transportation equipment	336		
Furniture	337		
Miscellaneous manufacturing	339		

M&E Capital Intensity

This capital intensity is defined as M&E capital stock per worker. The capital stock used is the private fixed non-residential geometric end-year net stock. To calculate Canada-U.S. capital intensity level gap, M&E capital stock in Canadian dollar for Canada is converted into US dollar using the M&E investment PPP values by industry. These PPP values are obtained from Rao, Tang and Wang (2004). The capital stock series is in chained-Fisher dollar and re-referenced to the year of 1999.

The Canadian data for M&E capital stock by industry are obtained from Statistics Canada (STC) CANSIM table 031-0002. The corresponding capital stock data for the U.S. come from the U.S. Bureau of Economic Analysis (BEA) fixed assets tables.

The data used for Canadian employment from 1997 onward is the total number of jobs from STC CANSIM table 383-0010. These data are extended back to 1987 using the growth rates of the total number of jobs from STC CANSIM table 383-0003. The employment data for the U.S. is the number of persons engaged in production. The source for the data from 1998 onward is the BEA NAICS-based GDP-by-industry tables, which are extended back to 1987 using the growth rates of the number of persons engaged in production from the BEA1987 SIC-based GDP-by-industry tables.

R&D Intensity

R&D intensity is defined as R&D expenditure to GDP ratio. The R&D expenditure data used for Canada is the intramural R&D expenditures that are obtained from the Science, Innovation and Electronic Information Division of Statistics Canada. The data from 1994 onward is NAICS-based. It is extended back to 1987 using the growth rates from the SIC-based data. The R&D data used for the U.S. is the total funds for industrial R&D performance. The sources of the data are Table A-7 and Table A-13, Survey of Industrial Research and Development, 1998, 2000, 2001, the U.S. National Science Foundation. NAICS-based data are available for the period of 1997 to 2001 and SIC-based data are available for the period of 1988-1998. The growth rates from SIC-based data are used to extend NAICS-based data back to 1988. The data for 1987 are assumed to be the same as those for 1988, and the data for 2002 and 2003 are assumed to be the same as those for 2001.

Total-Factor Productivity (TFP)

Canada-U.S. TFP gap is estimated using $\ln\left(TFP^{CA}/TFP^{US}\right) = \ln\left(LP^{CA}/LP^{US}\right) - \overline{w}\ln\left(k^{CA}/k^{US}\right)$, where LP is GDP at factor cost per worker, k is total capital intensity,[25] and $\overline{w}$ is the average capital share of income of the two countries.

GDP at factor cost in 1999 for Canada is obtained from STC CANSIM table 381-0013 and converted into US dollar using the Canada-U.S. bilateral GDP PPP values by industry from Rao, Tang and Wang (2004). The imputed value for owner-occupied dwellings is not included. The time series of GDP at factor cost in 1999 dollar are estimated using the growth rates of GDP at basic price in 1997 chained-Fisher dollar. The GDP at basic price in 1997 chained-Fisher dollar from 1997 onward come from STC CANSIM table 379-0017, which are extended back to 1987 using the growth rates of GDP at factor cost in 1992 constant dollar from STC CANSIM table 379-0001. The capital share of income is calculated using the data from STC CANSIM table 381-0013.

GDP at factor cost in 1999 for the U.S. is calculated using the data from BEA NAICS-based GDP-by-industry tables. The imputed value for owner-occupied dwellings is excluded using BEA NIPA table 7-12. The time series of GDP at factor cost in 1999 dollar are estimated using the chained-Fisher quantity index for GDP at market price from BEA NAICS-based GDP-by-industry tables. The capital share of income is calculated using the same source tables.

Real Wage Rate

[25] Total capital includes structure and M&E capital. Land and inventory are not included.

The real wage rate is defined as total labour compensation per worker, deflated using GDP deflator for total economy (1999=1). The Canadian data is converted into US dollar using the expenditure-based PPP exchange rate (STC CANSIM series v13930600).

The source of Canadian data on the total labour compensation for all jobs from 1997 onward is STC CANSIM table 383-0010. All these series are extended back to 1987 using the growth rate of labour compensation data from STC CANSIM table 381-0013. The total labour compensation for the U.S. is obtained from BEA NAICS-based GDP-by-industry tables.

Human capital or Skills

The share of hours worked by workers with university degree and above in total hours worked is used as the indicator of skills or human capital. The data of hours worked by industry and by education for both Canada and the U.S. for the period of 1987 to 2000 are obtained from Jorgensen and Lee (2001). The data are extended to 2003 using the average growth rates of past five years.

Short-term Real Interest Rate

Real interest rate is defined as the difference between nominal interest rate and inflation rate. The short-term nominal interest rates for both Canada and the U.S. are obtained from OECD outlook (A_CAN_IRS and A_USA_IRS). The inflation rates are calculated using Consumer Price Index (CPI) for all items. The source of CPI for Canada and the U.S. are STC CANSIM series v737344 and v11123, respectively.

Capacity Utilization

The output fluctuation is used as the indicator of capacity utilization because firms will adjust factor inputs accordingly in response to output change. The data used for output is real GDP by industry. The Hodrick-Prescott (H-P) filter is used to decompose GDP into two parts: the long-term trend and the short-term fluctuation. For normalization, the fluctuation is divided by the trend.

Tariff

The tariff data for the U.S. are computed using the U.S. International Trade Commission (USITC) database on imports (for consumption) and calculated duties. The Canadian tariff data for the period of 1987 to 2000 are obtained from Acharya *et al*. (2003). These data are extended to 2003 by exploiting the correlation between the Canadian and U.S. tariff data over the previous years.

Appendix C: Regression Results

Table 1c: Estimation results for TFP level gap equation
(Competition measured by the extent of anti-competitive PMR)

Dependent Variable: Canada-U.S. relative TFP (U.S.=1)

Independent Variable	Coefficient	t-Statistic
Competition intensity	0.0553***	2.90
M&E capital stock intensity	0.1410***	11.56
R&D intensity (lagged 1 year)	0.0088***	4.65
Skills or share of university hours (lagged 1 year)	0.0060	0.42
Capacity utilization	0.9469***	78.22
D_1	0.2786**	2.10
D_2	0.0514	1.08
D_3	-0.1457**	-2.16
D_4	0.1305**	2.38
D_5	0.0190	0.20
D_6	-0.1617**	-2.54
D_7	-0.2288***	-3.67
D_8	0.1122*	1.75
Adjusted R^2	0.9172	
Number of Obs.	576	
D.W statistics	1.9963	

Notes:
- PMR denotes product market regulation
- Estimation by Generalized Least Squares (Period SUR with Panel Corrected Standard Error).
- All variables (except capacity utilization) denote Canada-U.S. relative values (U.S.=1), in natural logarithm.
- Capacity utilization denotes difference in Canada-U.S. values.

*** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Source: Author's estimates.

Table 2c: Estimation results for M&E capital intensity gap equation
(Competition measured by the extent of anti-competitive PMR)

Dependent Variable: Canada-U.S. relative M&E capital intensity (U.S.=1)

Independent Variable	Coefficient	t-Statistic
Competition intensity	0.0930**	2.11
TFP Level (lagged 1 year)	0.1116***	4.40
Skills or share of university hours (lagged 1 year)	0.0606**	2.51
Real wage rate	0.5530***	16.62
Real interest rate (lagged 1 year)	-0.0003	-0.30
Capacity utilization	-0.0332***	-3.52
D_1	-0.4057	-1.24
D_2	-0.2968**	-2.47
D_3	-03300**	-1.98
D_4	-0.3128**	-2.27
D_5	-0.2214	-0.9509
D_6	-0.2178	-1.38
D_7	-0.4755***	-3.21
D_8	-1.5924	-10.75
Adjusted R^2	0.4418	
Number of Obs.	576	
D.W statistics	1.9963	

Notes: – PMR denotes product market regulation
– Estimation by Generalized Least Squares (Period SUR with Panel Corrected Standard Error).
– All variables (except capacity utilization and real interest rate) denote Canada-U.S. relative values (U.S.=1), in natural logarithm.
– Capacity utilization and real interest rate denote differences in Canada-U.S. values.
*** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Source: Author's estimates.

Table 3c: Estimation results for R&D intensity gap equation
(Competition measured by the extent of anti-competitive PMR)

Dependent Variable: Canada-U.S. relative R&D intensity (U.S.=1)

Independent Variable	Coefficient	t-Statistic
Competition intensity	0.4206***	2.80
TFP Level (lagged 1 year)	-0.1915	-1.58
Skills or share of university hours (lagged 1 year)	0.9454***	11.41
Capacity utilization	-0.2099	-1.16
D_1	0.9438***	5.33
D_2	-0.2707***	-4.11
D_3	-0.0252	-0.40
D_4	-0.3075***	-4.57
D_5	0.0798	0.87
D_6	1.0783***	5.97
D_7	0.5569***	5.30
D_8	0.8791***	9.96
Adjusted R^2	0.5595	
Number of Obs.	576	
D.W statistics	1.9964	

Notes:
- PMR denotes product market regulation
- Estimation by Generalized Least Squares (Period SUR with Panel Corrected Standard Error).
- All variables (except capacity utilization) denote Canada-U.S. relative values (U.S.=1), in natural logarithm.
- Capacity utilization denotes difference in Canada-U.S. values.

*** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Source: Author's estimates.

Table 4c: Contributions of competition intensity differential to the Canada-U.S. M&E, R&D, and TFP level gaps (in percent).

	1987-2003
M&E capital intensity	1.40
R&D intensity	18.99
TFP (total effect)	**8.25**
Direct effect	6.33
Indirect effect through M&E gap	1.50
Indirect effect through R&D gap	0.42

Notes: Contributions evaluated at the sample mean of the variables, where competition is measured by the extent of anti-competitive product market regulation.

Table 5c: Policy instruments induced competition

Dependent Variable: Price-cost margin or mark-up

	Canada		U.S.	
Independent Variable	Coeff.	Prob.	Coeff.	Prob.
PMR	11.3540	0.0000	17.8687	0.0000
Tariff rate	0.0169	0.0000	-0.0019	0.0000
Adjusted R^2	0.3806		0.1046	

Notes: – Results pertain to manufacturing industries as the available data allow computing tariff rates only for these industries.
– PMR denotes product market regulation.

Table 6c: Estimation results for TFP level gap equation
(Competition measured by 'adjusted' price-cost margin or markup)

Dependent Variable: Canada-U.S. relative TFP (U.S.=1)

Independent Variable	Coefficient	t-Statistic
Competition intensity	0.0112	1.45
M&E capital stock intensity	0.1147***	11.47
R&D intensity (lagged 1 year)	0.0118***	7.28
Skills or share of university hours (lagged 1 year)	0.0120	0.93
Capacity utilization	0.9643***	89.94
D_1	0.0549	0.61
D_2	-0.0962***	-2.89
D_3	0.0320	0.70
D_4	0.0881**	2.29
D_5	-0.1871***	-2.97
D_6	-0.2559***	-5.80
D_7	-0.2553***	-5.79
D_8	0.1651***	3.68
Adjusted R^2	0.9390	
Number of Obs.	576	
D.W statistics	1.9965	

Notes: – Estimation by Generalized Least Squares (Period SUR with Panel Corrected Standard Error).
– All variables (except capacity utilization) denote Canada-U.S. relative values (U.S.=1), in natural logarithm.
– Capacity utilization denotes difference in Canada-U.S. values.
*** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Source: Author's estimates.

Table 7c: Estimation results for M&E capital intensity gap equation
(Competition measured by 'adjusted' price-cost margin or markup)

Dependent Variable: Canada-U.S. relative M&E capital intensity (U.S.=1)

Independent Variable	Coefficient	t-Statistic
Competition intensity	0.0526***	4.71
TFP Level (lagged 1 year)	0.1126***	5.24
Skills or share of university hours (lagged 1 year)	0.0319	1.36
Real wage rate	0.5712***	19.31
Real interest rate (lagged 1 year)	-0.0008	-0.89
Capacity utilization	-0.0617***	-7.14
D_1	-0.3277	-1.54
D_2	0.3930***	4.93
D_3	0.5298***	4.83
D_4	0.1804**	2.01
D_5	-0.4756***	-3.14
D_6	-0.1981*	-1.94
D_7	0.0078	0.0808
D_8	-1.4311***	-14.22
Adjusted R^2	0.5999	
Number of Obs.	576	
D.W statistics	1.9965	

Notes: – Estimation by Generalized Least Squares (Period SUR with Panel Corrected Standard Error).
– All variables (except capacity utilization and real interest rate) denote Canada-U.S. relative values (U.S.=1), in natural logarithm.
– Capacity utilization and real interest rate denote differences in Canada-U.S. values.
*** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Source: Author's estimates.

Table 8c: Estimation results for R&D intensity gap equation
(Competition measured by 'adjusted' price-cost margin or markup)

Dependent Variable: Canada-U.S. relative R&D intensity (U.S.=1)

Independent Variable	Coefficient	t-Statistic
Competition intensity	0.3144*	1.75
TFP Level (lagged 1 year)	-0.2394	-1.53
Skills or share of university hours (lagged 1 year)	1.1197***	6.83
Capacity utilization	0.0185	0.11
D_1	1.0479***	4.11
D_2	-0.0016	-0.01
D_3	-0.1206	-0.85
D_4	-0.2178	-1.62
D_5	-0.9906***	-5.15
D_6	1.2138***	6.95
D_7	0.2922***	2.71
D_8	0.9202***	7.79
Adjusted R^2	0.3684	
Number of Obs.	576	
D.W statistics	1.9964	

Notes:
– Estimation by Generalized Least Squares (Period SUR with Panel Corrected Standard Error).
– All variables (except capacity utilization) denote Canada-U.S. relative values (U.S.=1), in natural logarithm.
– Capacity utilization denotes difference in Canada-U.S. values.

*** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Source: Author's estimates.