Services Trade and Structural Transformation*

Yuancheng Han†
University of Queensland

Jorge Miranda-Pinto‡
University of Queensland
Central Bank of Chile

Satoshi Tanaka§
University of Queensland

February 2022

Abstract

We study how service trade affects structural transformation and regional patterns of specialization. Using unique Canadian trade data, we document that i) inter-provincial and international trade of services have increased between 1992-2017; ii) inter-provincial trade is larger in services compared to goods; iii) structural transformation occurs from goods to tradable services, especially in tradable service-intensive provinces; and iv) there is significant regional specialization in producing goods and services across provinces. Using a spatial model of structural transformation and trade, we quantify the effects of service trade, domestic and international, on the share of the tradable-service sector and regional specialization. Our results indicate that domestic service trade has significantly contributed to the regional specialization. On the other hand, we find that, international service trade is more responsible for the increase of the tradable service share than domestic service trade in the aggregate Canadian economy.

JEL Classification: E20, F10, L16

Keywords: Services Trade, Structural Transformation, Regional Specialization

*We thank Ali Furkan Kalay for excellent research assistance. The usual disclaimers apply.
†Contact: uqyhan7@uq.edu.au
‡Contact: j.mirandapinto@uq.edu.au.
§Contact: s.tanaka@uq.edu.au.

1 Introduction

The reallocation of economic activity across manufacturing, agriculture, and service sectors (structural transformation) is one of the most striking and global macroeconomic facts of the last century (Herrendorf et al., 2014). Since the early contributions by Matsuyama (1992) and Echevarria (1995), researchers in the literature consider international trade as one of the important factors to account for structural transformation as well as non-homotheticity in preferences and differential productivity growth across sectors.

However, except for a few recent studies, the literaure has ignored one important question: What is the role played by trade in services, as opposed to trade in goods?[1] In this paper, using unique Canadian trade data, we start by documenting that, inter-regional and international trade of services are large in their volume, even comparable to goods trade especially for inter-regional trade, and that they are strongly correlated with regional sectoral composition. We also find that inter-provincial and international trade of services has increased over time during the period between 1992-2017. We then builda multi-sector and multi-region model with trade in goods and services to study the role of service trade in shaping regional and national structural transformation.

In Canada, where reliable data exists, inter-provincial trade of services—imports plus exports—is up to two times larger than international trade of services, while inter-provincial trade of goods is about half of international trade in goods. Besides its quantitative importance, incorporating inter-regional trade and trade of services is crucial to better understand the underlying sources of structural transformation. Most studies emphasize how trade in goods indirectly shapes the service share via affecting goods' relative price and household income (Uy et al. (2013)), and via the structure of intersectoral linkages between goods and services (Cravino and Sotelo (2019) and Sposi (2019)). We focus on the direct role that services trade, domestic and international trade, itself had played in shaping regional specilization and structural transformation.

We start by documenting the relationship between regional structural transformation and regional net exports in Canada. We divide the economy in three sectors: goods, tradable services, and non-tradable services. Non-tradable services are sectors that display a ratio between inter-regional exports to GDP smaller than 2%, while tradable services present a ratio larger or equal than 2%.[2] We show a strong positive correlation between sectoral GDP

[1]Eckert (2019) is the one of the few exceptions. He studies the role trade in services in accounting for regional inequality.

[2]Similar results hold when using slightly different thresholds and when we use international instead of inter-regional trade.

shares and trade. Domestic and international net exports of goods and services account for the cross-regional specialization patterns in sectoral shares between 1992-2017.

To rationalize our facts and to study the drivers of Canadian structural transformation we develop a three-sector model with multiple regions and the rest of the world in the spirit of Eaton and Kortum (2002). We introduce regional and international trade of services to the model. In each tradable sector, goods and tradable services, there is a continuum of competitive firms that engage in domestic and international trade. Each location also has a non-tradable service sector that domestically supplies non-traded services for final consumption. The economy also displays input-output likages. Household have non-homothetic preferences and heterogeneous income elasticities across consumption goods. We calibrate and estimate the model to match the observed production structure of Canadian provinces and the rest of the world. We use the model to perform different counterfactual exercises and quantitfy the role of domestic and international service trade in regional specialization and structural transformation.

Using the model calibrated to the Canadian provinces and the rest of the world, we run a set of counterfactual exercises to understand the roles of domestic and international service trade on regional specialization and structural transformation of the aggregate economy. The first exercise is to shut down domestic or international service trade to quantify the effects of each on the patterns of regional specialization. With the absence of domestic service trade, the real income shrinks for all Canadian provinces. These income effects dominate the price effects and decrease tradable service shares in most of the provinces in the counterfactual. In addition, we find that these effects are heterogeneous across provinces, ranging from -5.6% for Ontario to 28.8% for Northwest Territories & Nunavut, greatly reducing the regional specialization in tradable service production in the counterfactual. In the second exercise, we decompose the changes in the sectoral value-added shares into those driven by price effects and those by income effects. We then further investigate those changes in the counterfactual economies without domestic or international service trade. We find that, while both domestic and international service trade affect the changes in the tradable service share through price effects, international trade is the one that drives the rise of the tradable service share in the aggregate Canadian economy.

Our work makes contributions to two strands of literature. First, we contribute to the literature on structural transformation and trade. Uy et al. (2013) extends the canonical model of structural transformation and incorporates international trade of goods. The authors document that trade shocks are important determinants in the evolution of agriculture and manufacturing sectors. The authors also emphasize the role of international trade in affecting speclialization patterns and country's income in response to changing sectoral productivity. Sposi (2019) extend the model in Uy et al. (2013) to study the role input-output linkages in accounting for the hump shape of industry's share in value added across countries. Cravino and Sotelo (2019) study the role of international trade in shaping structural change and the skill premium. Our paper contributes to this literature by studying the role that inter-regional and international trade of services has had in the process of structural transformation. Our work also contributes to Buera and Kaboski (2012) Duarte and Restuccia (2019); Duernecker et al. (2019) by proposing an alternative approach to disaggregate service sectors, based on their tradability, in the study of the drivers of structural transformation.

Our paper also relates to the literature that studies the drivers of regional specialization. Recent work in this literature are, e.g., Coşar and Fajgelbaum (2016) and Fajgelbaum and Redding (2018) who study the role of trade in goods in shaping regional and sectoral specialization. The authors use Chinese and Argentinian data, respectively, two motivate and validate their models. Eckert and Peters (2018) also investigate the patterns of regional structural transformation in the U.S. in a model with inter-regional trade of goods. Different from these papers, we use detailed Canadian data on regional and international trade of services to quantify the role that increased service trade has had in regional specialization and Canadian structural transformation.

2 Stylized facts

In this section, we present a number of stylized facts regarding regional specialization and structural transformation in Canada. We also present evidence of the relationship between regional and international trade of services (and goods) and the patterns of regional specialization and structural transformation.

2.1 Structural transformation in Canada

Figure 1 depicts the structural transformation pattern across sectors in Canada from 1992 to 2017. It is clear that economic activities shift from goods sectors to tradable services sectors over this period: value added share for goods fell 9.7 percentage points (27% decrease), while tradable services rose steadily 8.4 percentage points (17% increase).

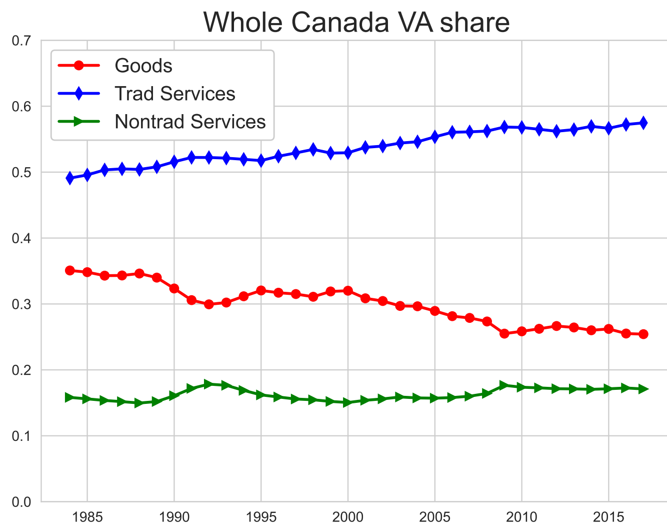

FIGURE 1 – Economic sectors as a share of GDP in Canada, 1992–2017, Canada
Notes: We drop oil industry from goods sector, due to the high volatility

2.2 Domestic and international service trade patterns

Figure 2 shows levels and time evolution of domestic (inter-provincial) and international trade during the period 1992-2017 in Canada. Domestic and international service tarde volumes (imports plus exports) amount to 12–23% of the Canadian GDP per year, respectively. Domestic trade volume is increasing over time, while the international trade volume is fairly stable during the same period.

In Figure 3, we compare the patterns of domestic and international service trade to those of goods' trade. We observe distinct patterns of in domestic and international trade of goods and services. In domestic trade, goods and service trade volumes are similar in levels but have different trend. Domestic service trade is trending up, while domestic trade of goods is slightly trending down. Indeed, by 2015 there is more trade of services than trade of goods across Canadian provinces. On the other hand, international trade of goods substantially exceeds service trade. This pattern is slightly affected by a downward trend in international trade of goods . These two figures evidence the potential importance of domestic and international service trade on the structural transformation of the Canadian economy.

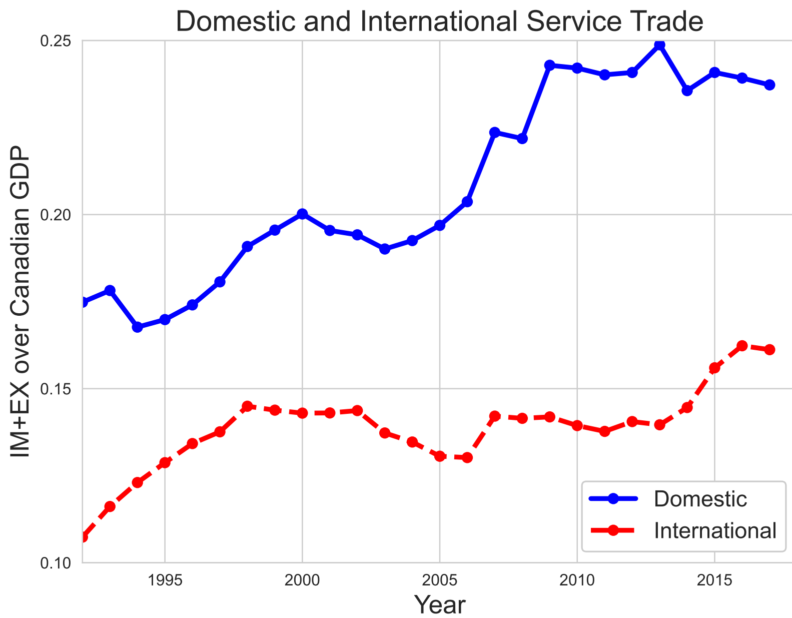

FIGURE 2 – Domestic (Inter-provincial) and International Service Trade as a Fraction of GDP, 1992–2017, Canada

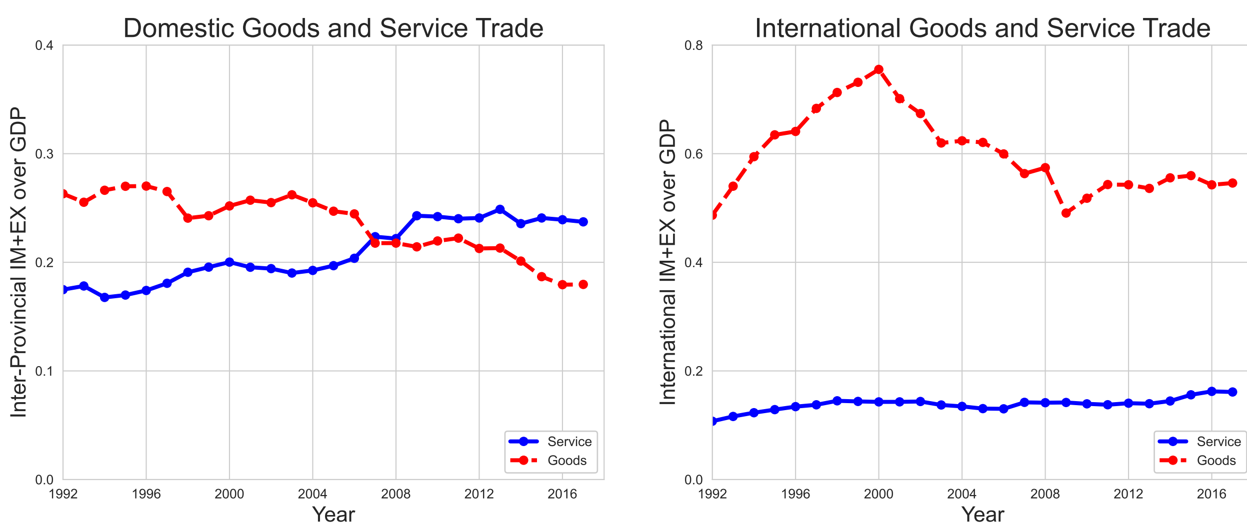

FIGURE 3 – Domestic (Inter-provincial) and International Goods and Service Trade Volume (Exports + Imports) Relative to GDP, 1992–2017, Canada

2.3 Regional specialization

In this section, we document the cross-section patterns in regional specialization. Figure 4 depicts the time-average value-added shares of goods and tradable services across Canadian provinces. We observe remarkable heterogeneity in regional specializations.

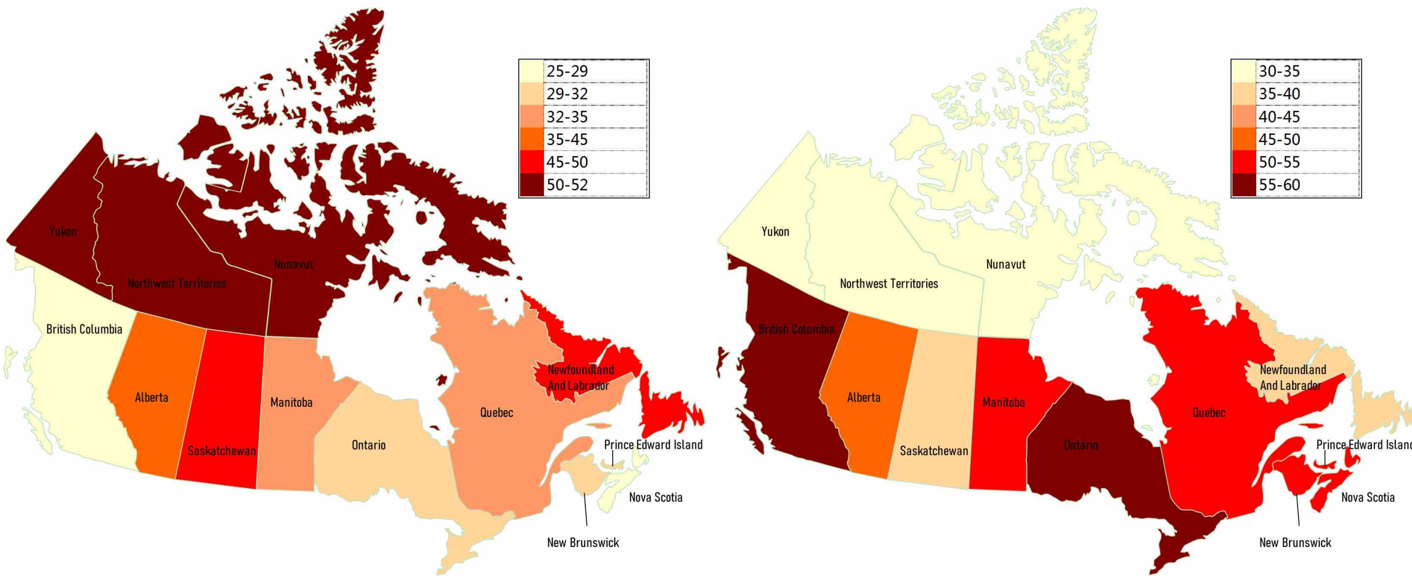

FIGURE 4 – The average Sectoral Value Added Shares across Canadian Provinces: Goods vs Tradable Services

In contrast to the clear patterns of regional specializations in value added shares, the consumption expenditure shares show notable homogeneity across regions. Figure 5 illustrates the time-average household consumption expenditure shares of goods and tradable services across Canadian provinces. The variations in consumption expenditure shares are within 10% across provinces, much smaller than those in value added shares.

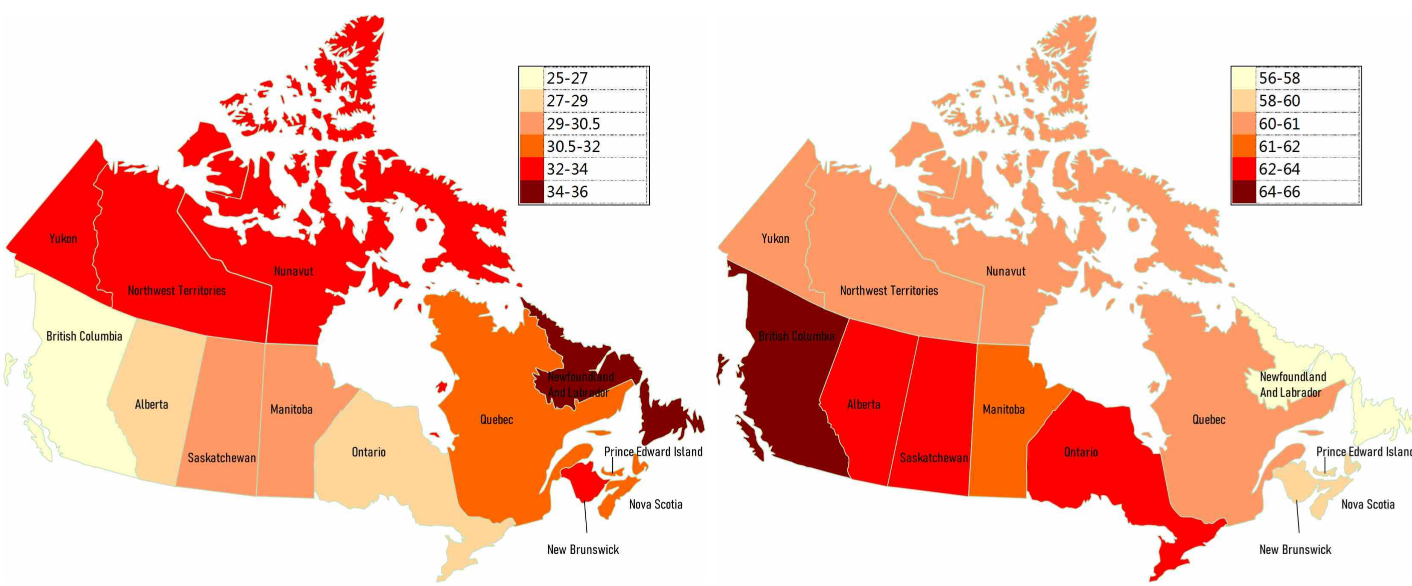

FIGURE 5 – The average Consumption Expenditure Shares across Canadian Provinces: Goods vs Tradable Services

2.4 Trade and value-added shares

In this section, we provide empirical support for the role of trade in driving sectoral GDP across Canadian provinces. We show that not only international trade in goods matters for structural tranformation but also, and arguably more important, domestic (inter-provincial) and international trade in services do. Figures 6 and 7 show the correlations between sectoral GDP shares and sectoral net exports as a share of GDP. As evident in the figures, not only goods but also service trade are strongly correlated with value added shares. It is also worth noting that these relationships hold both in domestic and international trade.

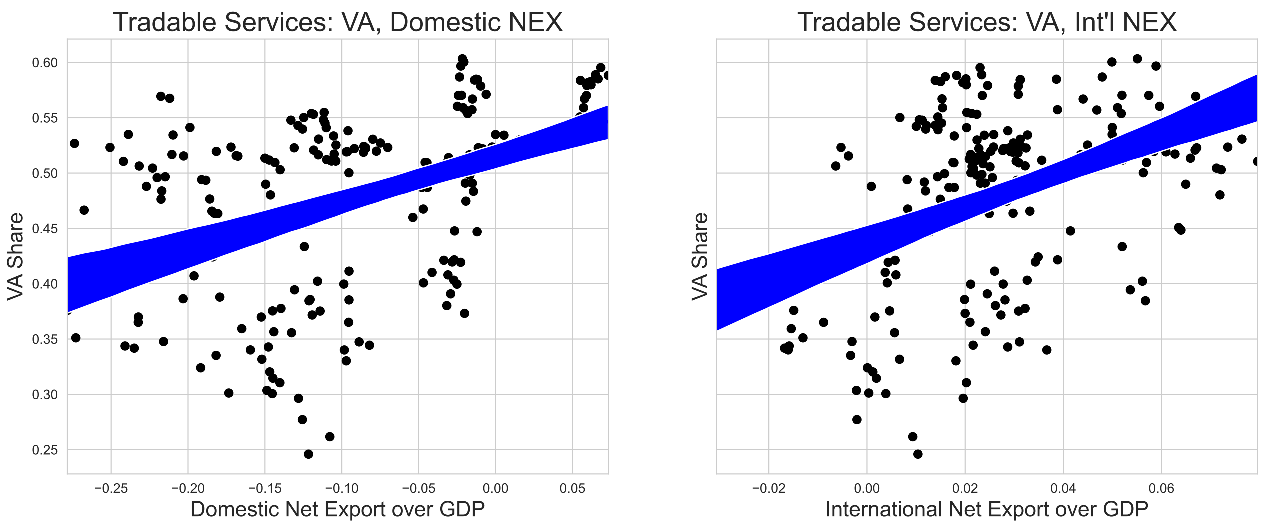

FIGURE 6 – The Correlation of the Value Added Share and Net Domestic/International Export in Tradable Services across Canadian Provinces, 1992-2017

The empirical evidence thus suggests that domestic and international trade in services seem to play an important role in regional structural transformation. In the next section, we investigate in greater details which sectors in particular are driving the increase in service trade and service trade value added shares we observe.

In the next section, we develop a model that allows us to answer the following question: What are the main drivers of regional and national structural transformation in Canada? We will use the model to investigate the role that service trade, sectoral productivity, and non-homotheticity in preferences have played in shaping sectoral composition.

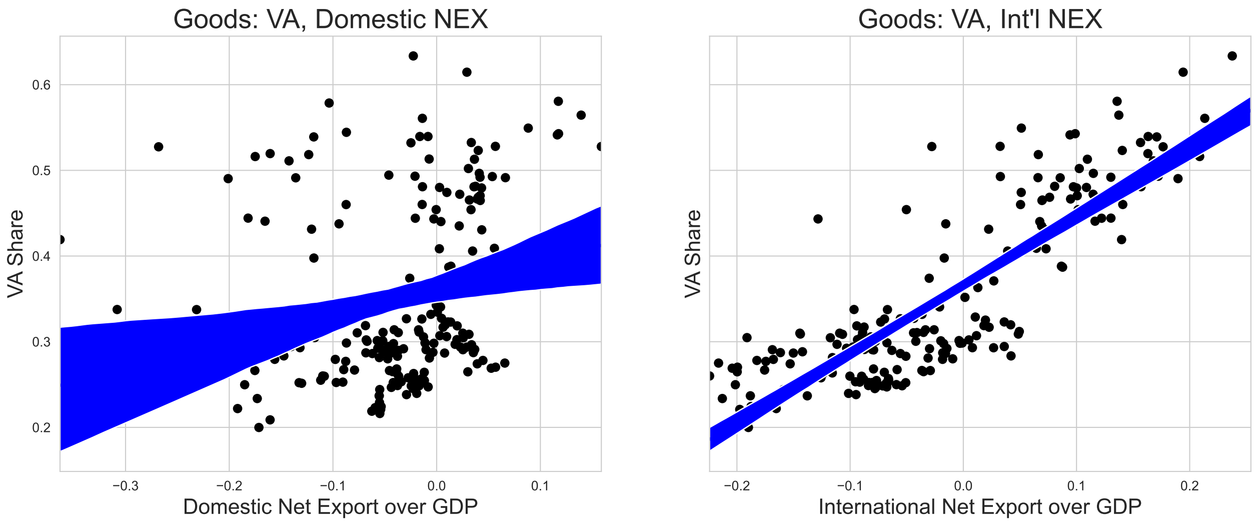

FIGURE 7 – The Correlation of the Value Added Share and Net Domestic/International Export in Goods across Canadian Provinces, 1992-2017

3 Model

Our model extends the model in Caliendo and Parro (2014) to account for interregional and international trade in services and non-homothetic preferences. Our objective is, through the lens of a three-sector multi-regions model, to analyze the role of inter-regional trade and international trade of goods and services in shaping Canada's structural transformation between 1997-2017. We consider two countries: Canada and the Rest of the World (ROW). In Canada, we assume there are J provinces. In each province, there are three sectors, goods (g), tradable services (sm), and non-tradable services (sn). Firms use labour and intermediate inputs as factor of production.

We assume that firms in each province export and import goods and tradable servcies (for intermediate input purposes) with other provinces, as well as with the ROW. Trade is costly and we model that through the existence of iceberg costs. As in Eaton and Kortum (2002), trade has Ricardian motives. Producers differ in their productivity and the trade costs associated in trading with different regions. In equilibrium, firms source the cheapest intermediate input. There is a representative household in each province who consumes the three goods produced domestically.

3.1 Production and trade

In province i and sector $k \in \{g, sm, sn\}$ there is a continum of goods' producers $z \in [0,1]$ whose production technology is given by

$$Y_{i,t}^{k}(z) = Z_{i,t}^{k}(z)\left[T_{i,t}^{k}L_{i,t}^{k}(z)\right]^{\lambda_{i,k}}\left[\prod_{n=g,sm,sn}\left(M_{i,t}^{k,n}(z)\right)^{\gamma_{i,k,n}}\right]^{1-\lambda_{i,k}}, \tag{3.1}$$

where $Y_{i,t}^{k}(z)$ is output, $Z_{i,t}^{k}(z)$ denotes variety-specific component of gross output productivity, $L_{i,t}^{k}(z)$ is labor input, and $M_{i,t}^{k,n}(z)$ is sector-n's good used as intermediate input in the production of sector k's good. Note that $\{Y_{i,t}^{k}(z), Z_{i,t}^{k}(z), L_{i,t}^{k}(z), M_{i,t}^{k,n}(z)\}$ are all variety-sector-province-year specific. $T_{i,t}^{k}$ governs the fundamental exogenous component of measured value added productivity, namely production efficiency. The two production parameters, $\lambda_{i,k}$ and $\gamma_{i,k,n}$, determine the value added share and the share of intermediates from sector n in the production function, respectively. As in Eaton and Kortum (2002), we assume that, in every period, gross output productivity $Z_{i,k}$ is the realization of random efficiency drawn from a Fréchet distribution.: $F_{i,t}^{k}(Z) = e^{-Z^{-\theta}}$, where $\theta > 1$ governs the within region and sector variarion in firms' productivity. A bigger θ implies lower dispersion in productivities. Therefore, as in Sposi (2019), we can refer the measured gross output productivity $A_{i,t}^{k}(z)$ as the composite $Z_{i,t}^{k}(z)\, T_{i,t}^{k\,\lambda_k}$.

We assume the existence of iceberg costs in shipping goods and services to different regions. Shipping costs include tariffs, transportation costs, and other barriers to trade. In particular, we assume iceberg costs $\tau_{ij,t}^{g}$ for shipping good z from the goods sector to country i from country j. As standard in the literature, we assume that the trade costs are zero within a country, $\tau_{ii,t}^{g} = \tau_{ii,t}^{sm} = \tau_{ii.t}^{sn} = 1$ and that the trade cost of non-tradable sector is infinity ($\tau_{ji,t}^{sn} \to \infty$).

Markets are competitive. From the firms' cost minimization problem, subject to technology (3.1), the price of shipping good z in sector k from region i to region j is

$$p_{i,t}^{k}(z) = \frac{v_{i,t}^{k}\tau_{ji,t}^{k}}{A_{i,t}^{k}(z)} = \frac{v_{i,t}^{k}\tau_{ji,t}^{k}}{Z_{i,t}^{k}(z)\, T_{i,t}^{k}}$$

where $\tau_{ji} \leq 1$ is the trade cost of shipping goods or services from region i to region j and

$v_{i,t}^k$ is the unit cost of input bundle given by

$$v_{i,t}^k = \lambda^{i,k\left(-\lambda^{i,k}\right)} \left(\frac{\prod_{n=g,sm,sn} \gamma^{i,k,n^{-\gamma^{i,k,n}}}}{1-\lambda^{i,k}} \right) (w_{i,t})^{\lambda_k} \left(\prod_{n=g,sm,sn} \left(P_{i,t}^n\right)^{\gamma^{i,k,n}} \right)^{1-\lambda^k} \tag{3.2}$$

where $w_{i,t}$ is the wage and $P_{i,t}^n$ is the price of sector-n's composite good .

In each sector k, competitive buyers buy good $Q_{i,t}^k(z)$ either from the domestic (country i's) or the foreign (country j's) supplier whichever can offer a lower price, $\hat{p}_{i,t}^k(z) = \min\left\{\sum_{j=1}^J p_{j,t}^k(z)\right\}$, where J is the total number of regions. Then, as in Eaton and Kortum (2002), under the Fréchet distribution assumption, the price of composite good $k \in \{g, sm, sn\}$ in country i is $P_{i,t}^k = \Gamma\left(\Phi_{i,t}^k\right)^{-\frac{1}{\theta}}$, where the constant Γ is the Gamma function evaluated at $\left(1-\frac{\eta-1}{\theta}\right)^{\frac{1}{1-\eta}}$, and $\Phi_{i,t}^k = \sum_{j=1}^J \left(T_{j,t}^{k\ \lambda_{i,k}} v_{j,t}^k \tau_{i,j,t}^k\right)^{-\theta}$[3]. Thus, $\Phi_{i,t}^k$ describes country i's access to global production technologies in sector k scaled by the relevant unit costs for inputs and trade costs. For composite good in sector $k \in \{g, sm, sn\}$, the price is

$$P_{i,t}^k = \Gamma\left[\sum_{j=1}^J \left(T_{j,t}^{k\ \lambda_{i,k}} v_{j,t}^k \tau_{i,j,t}^k\right)^{-\theta}\right]^{-\frac{1}{\theta}} \tag{3.3}$$

Trade patterns in this model depend on the dispersion of productivities (comparative advantage) and trade barriers (geographic or economic). A lower value of θ generates more room for comparative advantage, rather than trade barriers, in driving trade patterns. Eaton and Kortum (2002) show that, under the Fréchet distribution assumption, we can derive the share of country j's expenditure on sector-k goods from country i, as

$$\pi_{j,i,t}^k = \frac{\left(T_{i,t}^{k\ \lambda_{i,k}} v_{i,t}^k \tau_{j,i,t}^k\right)^{-\theta}}{\Phi_{j,t}^k}, \tag{3.4}$$

which equals the probability of importing sector-k goods from country i in country j. Thus, country j's share of imports in the total expenditure depends on country i's average productivity in industry k, the cost of the input bundle, and trade costs to ship goods from country i to country j.

[3]To ensure a well-defined price index, we assume $\eta - 1 < \theta$ which is standard in the literature. Under this assumption, the parameter η, which governs the elasticity of substitution across goods within a sector, can be ignored because it appears only in the constant term Γ.

3.2 Household preferences

The representative household in region i with non-homothetic CES preferences maximizes the aggregate per-capita consumption C_i, which is implicitly defined as:

$$\sum_k \omega_k^{\frac{1}{\sigma_k}} \left(\frac{C_i^k}{L_i}\right)^{\frac{\sigma-1}{\sigma_k}} \left(\frac{C_i}{L_i}\right)^{\frac{\epsilon_k-\sigma}{\sigma_k}} = 1 \tag{3.5}$$

where C_i^k is the consumption of sector-k composite goods; ω_k denotes the relative weight of consumption bundle in sector k; σ_k is the price elasticity of substitution and ϵ_k shapes the income elasticity of demand for sector k. Preference parameters are constant across regions. This implicit utility function is also used in Comin et al. (2021), Lewis et al. (2020) and Sposi (2019). Details are outlined in appendix B.1.To ensure the monotonicity and quasi-concavity of aggregate utility C_i, we restrict income elasticity $\epsilon_k > 0$ and either price elasticity (i) $0 < \sigma_k < 1$ or (ii) $\sigma_k > 1$.

As in Duernecker et al. (2019), we can construct a nested non-homothetic CES utility function. In the outer layer, aggregate real consumption, C_i, is a non-homothetic CES aggregator of real goods and aggregate services consumption, C_i^g and C_i^s, which comes from (3.5) by setting $\sigma = \sigma_g$, $k \in \{g, s\}$:

$$\frac{C_i}{L_i} = \left(\omega_g^{\frac{1}{\sigma_g}} \left(\frac{C_i}{L_i}\right)^{\frac{\epsilon_g-1}{\sigma_g}} \left(\frac{C_i^g}{L_i}\right)^{\frac{\sigma_g-1}{\sigma_g}} + \omega_s^{\frac{1}{\sigma_g}} \left(\frac{C_i}{L_i}\right)^{\frac{\epsilon_s-1}{\sigma_g}} \left(\frac{C_i^s}{L_i}\right)^{\frac{\sigma_g-1}{\sigma_g}}\right)^{\frac{\sigma_g}{\sigma_g-1}}, \tag{3.6}$$

In the inner layer, real consumption of aggregate services, C_i^s, is decomposed into real consumption of tradable and nontradable services, C_i^{sm} and C_i^{sn}, by setting $\sigma = \sigma_s$, $k \in \{sm, sn\}$ in (3.5):

$$\frac{C_i^s}{L_i} = \left(\omega_{sm}^{\frac{1}{\sigma_s}} \left(\frac{C_i}{L_i}\right)^{\frac{\epsilon_{sm}-1}{\sigma_s}} \left(\frac{C_i^{sm}}{L_i}\right)^{\frac{\sigma_s-1}{\sigma_s}} + \omega_{sn}^{\frac{1}{\sigma_s}} \left(\frac{C_i}{L_i}\right)^{\frac{\epsilon_{sn}-1}{\sigma_s}} \left(\frac{C_i^{sn}}{L_i}\right)^{\frac{\sigma_s-1}{\sigma_s}}\right)^{\frac{\sigma_s}{\sigma_s-1}} \tag{3.7}$$

For $\epsilon_k = 1$, the nested utility function collapsed into standard CES utility with homothetic demand function. By setting $\sigma_k = \epsilon_k = 1$, representative household behaves a Cobb-Douglas preference.

3.3 Budget constraint

The budget constraint of representative household is

$$P_i^g C_i^g + P_i^{sm} C_i^{sm} + P_i^{sn} C_i^{sn} + \iota_i w_i L_i = w_i L_i + \xi L_i. \tag{3.8}$$

s.t.

$$P_i^g C_i^g + P_i^{sm} C_i^{sm} + P_i^{sn} C_i^{sn} = P_i C_i \tag{3.9}$$

where $C_{i,t}^k$ is the consumption of sector-k composite goods for $k \in g, sm, sn$, $w_{i,t}$ is the household's wage rate from supplying his unit labour inelastically and $P_{i,t}^k$ is the price of the sector-k composite good. As in Caliendo et al. (2017), the model measures trade imbalances as net payment from a global portfolio. Specifically, we assume that in each period, representative household in region i spends a fraction ι_i of income on a global global portfolio of assests. The returns to this fraction of income is equally distributed lump-sum to all households and ξ specifies this per capita return from global portfolio. Therefore, $\iota_i w_i L_i - \xi L_i$ governs regional trade imbalance that emerges from both inter-provincial and international transfers and satisfies:

$$\sum_i \iota_i w_i L_i = \xi \sum_i L_i \tag{3.10}$$

Following Lewis et al. (2020), ι_i is modeled as the ratio of net export to GDP for province i. Given that the net export of Canadian provinces and rest of the world sum to zero, the lump sum transfer ξ will equal to 0 in open economy. In counterfactuals, ξ will absorb the trade imbalances caused by changes in trade costs.

3.4 Equilibrium

Within a country, we assume perfect competition for all the goods and factor markets. In particular, we assume labor is mobile across sectors but immobile across regions or countries.[4] Let $L_{i,t}$ denote total labor endowment in county i, and $L_{i,t}^k$ labor employed in sector k. Then, the following labor market clearing condition holds every period within the country

$$L_{i,t} = L_{i,t}^g + L_{i,t}^{sm} + L_{i,t}^{sn}. \tag{3.11}$$

[4] In the future, we plan to relax the assumption of labor immobility across regions of the same country.

The goods and services markets also clear every period. For each sector $k \in g, sm, sn$, we have

$$Q_{i,t}^{k} = C_{i,t}^{k} + \sum_{n=g,sm} (1-\lambda^{n})\,\gamma^{n,k} \sum_{j=1}^{J} \frac{\pi_{j,i,t}^{n} P_{j,t}^{n} Q_{j,t}^{n}}{P_{i,t}^{k}} + (1-\lambda^{sn})\,\gamma^{sn,k} \frac{P_{i,t}^{sn} Q_{i,t}^{sn}}{P_{i,t}^{k}}. \tag{3.12}$$

The above equations relate the total production of goods or services in sector k, $Q_{i,t}^{k}$, to the sum of the quantity demanded for domestic final production, $C_{i,t}^{k}$, for the usage of intermediate inputs in the production of domestic tradable goods and services, and the usage of intermediate inputs in the production of domestic non-tradable services.

Given country-specific labor endowment $\{L_{i,t}\}$, trade costs $\left\{\tau_{i,j,t}^{g}, \tau_{i,j,t}^{sm}\right\}$ productivity process $\left\{T_{i,t}^{g}, T_{i,t}^{sm}, T_{i,t}^{sn}\right\}$, and common structural parameters $\left\{\sigma, \eta, \theta, \left\{\lambda^{k}, \gamma^{k,n}, \bar{C}^{k}, \omega^{k}\right\}_{n,k\in\{g,sm,sn\}}\right\}$, a competitive equilibrium of the model is defined as follows.

Definition 1. *A competitive equilibrium is a sequence of goods and factor prices* $\left\{P_{i,t}^{g}, P_{i,t}^{sm}, P_{i,t}^{sn}, w_{i,t}\right\}_{i\in J}$, *allocations* $\left\{L_{i,t}^{g}, L_{i,t}^{sm}, L_{i,t}^{sn}, Q_{i,t}^{g}, Q_{i,t}^{sm}, Q_{i,t}^{sn}, C_{i,t}^{g}, C_{i,t}^{sm}, C_{i,t}^{sn}\right\}_{i\in J}$ *and trade shares* $\left\{\pi_{i,j,t}^{g}, \pi_{i,j,t}^{sm}\right\}_{i,j\in J}$ *such that, given prices, the allocations solve the firms' maximization problems associated with technologies* (3.1)*, an the household's maximization problem characterized by* (3.6)-(3.8)*, and satisfy the market clearing conditions* (3.11)-(3.12)*.* [5]

4 Calibration

In this section, we calibrate and estimate the key parameters of the model and perform several quantitative exercises to study the role that trade, in particular service trade, has played in shapping Canadian regional specialization and Canadian national structural transformation. We can split our calibration into (i) Preference parameters $(\omega_k, \sigma_k, \epsilon_k)$ (ii) Production coefficients $(\lambda_{ik}, \gamma_{ikn})$. (iii) Parameters from past literatures: trade elasticity θ and elasticity of substitution within a sector η. In our paper, preference parameters are common across all provinces, while production coefficients are province-specific. This section will also discuss procedures to build net export, value added in benchmark model.

4.1 Preference parameters

Preference parameters includes: four relative weights $\{\ \omega_g, \omega_s, \omega_{sm}, \omega_{sn}\}$; two elasticities of substitution $\{\sigma_g, \sigma_s\}$ and four elasticities of income $\{\epsilon_g, \epsilon_s, \epsilon_{sm}, \epsilon_{sn}\}$. We gather data on

[5] Equilibrium conditions are outlined in detail in Appendix.

household final consumption expenditure in current and constant price at sub-sectoral level. This sub-sectoral data enables us to construct nominal and real sectoral expenditure through aggregation. We use Canadian provincial employment data as labor demand L_{it}. Details of data construction are described in appendix A.2. We then generate sectoral consumption price index as the ratio of nominal to real household consumption.

We structurally estimate the elasticities of both income and price channels by minimizing the distance between the observed sectoral expenditures and those implied by the model given the observed prices. Combining (3.6)-(3.8) and take the first-order condition, we generate model implied relative sectoral expenditure shares as two layers:

$$\frac{P_{it}^{s} C_{it}^{s}}{P_{it}^{g} C_{it}^{g}} = \frac{\omega_s}{\omega_g} \left(\frac{P_{it}^{s}}{P_{it}^{g}} \right)^{1-\sigma_g} \left(\frac{C_{it}}{L_{it}} \right)^{\epsilon_s - \epsilon_g} \tag{4.1}$$

$$\frac{P_{it}^{sm} C_{it}^{sm}}{P_{it}^{sn} C_{it}^{sn}} = \frac{\omega_{sm}}{\omega_{sn}} \left(\frac{P_{it}^{sm}}{P_{it}^{sn}} \right)^{1-\sigma_s} \left(\frac{C_{it}}{L_{it}} \right)^{\epsilon_{sm} - \epsilon_{sn}} \tag{4.2}$$

Equations 4.1 and 4.2 enable us to separate the relative price effect and income effect respectively. We can calibrate preference parameters by jointly minimising two squared distances between model-implied sectoral expenditures ratio and those from data:

$$\min_{\sigma_g, \sigma_s, \epsilon_g, \epsilon_{sn}} \sum_{i,t} \left(\frac{\omega_s}{\omega_g} \left(\frac{\widehat{P_{it}^{s}}}{\widehat{P_{it}^{g}}} \right)^{1-\sigma_g} \left(\frac{C_{it}}{\widehat{L_{it}}} \right)^{\epsilon_s - \epsilon_g} - \frac{P_{it}^{s} C_{it}^{s}}{\widehat{P_{it}^{g} C_{it}^{g}}} \right)^2 + \left(\frac{\omega_{sm}}{\omega_{sn}} \left(\frac{\widehat{P_{it}^{sm}}}{\widehat{P_{it}^{sn}}} \right)^{1-\sigma_s} \left(\frac{C_{it}}{\widehat{L_{it}}} \right)^{\epsilon_{sm} - \epsilon_{sn}} - \frac{\widehat{P_{it}^{sm} C_{it}^{sm}}}{\widehat{P_{it}^{sn} C_{it}^{sn}}} \right)^2 \tag{4.3}$$

s.t.

$$\omega_g + \omega_s = 1 \tag{4.4}$$

$$\omega_{sm} + \omega_{sn} = 1 \tag{4.5}$$

$$\epsilon_s = 1 \tag{4.6}$$

$$\epsilon_{sm} = 1 \tag{4.7}$$

$$P_{it}^{s} = \left(\omega_{sm} \left(\frac{C_{it}}{\widehat{L_{it}}} \right)^{\epsilon_{sm}-1} \widehat{P_{it}^{sm}}^{1-\sigma_s} + \omega_{sn} \left(\frac{C_{it}}{\widehat{L_{it}}} \right)^{\epsilon_{sn}-1} \widehat{P_{it}^{sn}}^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}} \tag{4.8}$$

$$P_{it} C_{it} = \left(\omega_g \left(\frac{C_{it}}{\widehat{L_{it}}} \right)^{\epsilon_g - \sigma_g} \widehat{P_{it}^{g}}^{1-\sigma_g} + \omega_s \left(\frac{C_{it}}{\widehat{L_{it}}} \right)^{\epsilon_s - \sigma_g} P_{it}^{s\,1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}} \tag{4.9}$$

Table 1 – Preference parameters values

Preference parameters		Estimates	S.E.
ω_g	Relative weight for Goods	0.33	-
ω_{sm}	Relative weight for Tradable Services	0.89	-
ϵ_g	Income elasticity on Goods	0.41	0.03
ϵ_s	Income elasticity on Services	1.00	-
ϵ_{sn}	Income elasticity on Nontrad. Services	1.06	0.03
ϵ_{sm}	Income elasticity on Tradable Services	1.00	-
σ_g	Price elasticity for Goods and Services	0.59	0.04
σ_s	Price elasticity for Trad. and Nontrad. Services	0.32	0.10

Notes: We compute standard errors by bootstrapping the same number of province-time observations with replacement. We apply the calibration procedure to the simulated data in each replication and record the value of calibrated preference parameters for 1000 repetitions.

where ”hat” denotes observations from data. We impose the sum of relative weight ω_k equal to 1 in equation (4.4) and (4.5) respectively. Similar to Lewis et al. (2020), we adjust the value of ω_k to Canadian average expenditure share in 1992. As ω_k is identical across different provinces, we introduce the province fixed effects to make up the deviation between provincial sectoral expenditure share and ω_k in 1992. Provided that income elasticities are calibrated only in differences, we normalize ϵ_s and ϵ_{sm} to one, which is only a monotonic transformation of utility function Comin et al. (2021).

We exploit the nonlinear least squares model in equation (4.1) with panel data for 11 Canadian provinces during the period 1992 - 2017. This enables us to calibrate the rest four parameters, $\{\epsilon_g, \epsilon_{sm}, \sigma_g, \sigma_s\}$. The calibration strategy goes as follows: (i) We give a initial guess to four preference parameters $\{\epsilon_g, \epsilon_{sm}, \sigma_g, \sigma_s\}$; (ii) We impute service price P^s_{it} as a function of aggregate real consumption C_{it} using equation (4.8) for each province every year; (iii) We substitute constructed service price P^s_{it} into equation (4.9). The aggregate expenditure, $P_{it}C_{it}$, becomes a non-linear function with only one unknown C_{it}; (iv) We feed the equation (4.9) with data on aggregate expenditure, goods price and total employment. Provided that total expenditure is strictly increasing with C_{it}, we can solve out C_{it} in a one-to-one mapping; (v) We revisit (4.8) and compute P^s_{it} given C_{it} for each province every year; (vi) We update parameters values $\{\epsilon_g, \epsilon_{sm}, \sigma_g, \sigma_s\}$ by minimising the deviation in . (vii) We go back to step (ii) with updated parameters and keep repeating the procedure until the objective function reaches its global minimum value.

Estimated preference parameters are shown in Table 1. Our estimates of preference parameters satisfies the basic regularity conditions such as monotonicity and quasi-concavity, given $\epsilon > 0$ and $\sigma \neq 1$ for all sectors. For outer layer, $\sigma_g = 0.59$, which indicates that goods and services are complements. Our estimates of σ_g is higher than that in Duernecker et al. (2019), 0.30. They collects price data in the US dating back to 1947 and longer sample period allows for more low-price observations in early years. Our σ_g is also higher than Lewis et al. (2020), 0.59 versus 0.16. They use time series data for 26 countries, including emerging countries such as China and India. Thus, the sectoral price data indicates a faster growth than ours. $\epsilon_g = 0.41$ implies that goods are necessity and services are luxuries. Our estimate of $\epsilon_s - \epsilon_g$ is higher than estimate in Duernecker et al. (2019) of 0.32. Our estimation uses pure household consumption data while Duernecker et al. (2019) exploit value added data instead. Consumption share in services rises faster than value added share in services, which brings about a stronger income effect in our benchmark estimation.

For inner layer, we obtain elasticity of substitution $\sigma_s = 0.31$, implying that tradable and nontradable services are complements. [6] The result contrasts Duernecker et al. (2019) where $\sigma_s = 1.03$, due to the different classification strategy. We categorize service sector based on the ratio of trade volume to GDP while they focus on productivity growth of each sub-sector. Our estimate of $\epsilon_s n = 1.06$ shows tradable services are necessities and nontradable services are luxuries. Compared with tradable services like wholesale and transportation, nontradable services including private schools and private hospitals are luxuries. The estimate is consistent with Duernecker et al. (2019) where education and health care are classified as stagnant services.

The upper panel of figure 8 illustrates the calibrated consumption expenditure ratio of aggregate services to goods from the model and the data. The calibration matches the targeted moment very well with data points closely located on both sides of 45° line. This implies Canadian consumers behave similarly on allocating between goods and services. On the other hand, the middle panel maps the model fit on the consumption ratio of non-tradable services to tradable services. Provinces with large model-data departures are Prince Edward Island (PE) and Northwest Territories (NW). The reason is the different structural patterns in PE and NW: in contrast to other 9 provinces, the non-tradable to tradable services consumption ratio in PE and NW is decreasing overtime. However, our calibrated preference parameters will generate a increasing pattern on nontradable-tradable consumption ratio, which brings some measurement noises for these two provinces. [7]

[6] If we take average on σ_g and σ_s, the result will get close to that in Comin et al. (2021) and Sposi (2019) where single price elasticity is used. We also do an alternative model with single price elasticity and $\sigma = 0.44$ in that model.

[7] Figure **??** and **??** in Appendix illustrate the details of sectoral consumption expenditure share fot benchmark and data at provincial level.

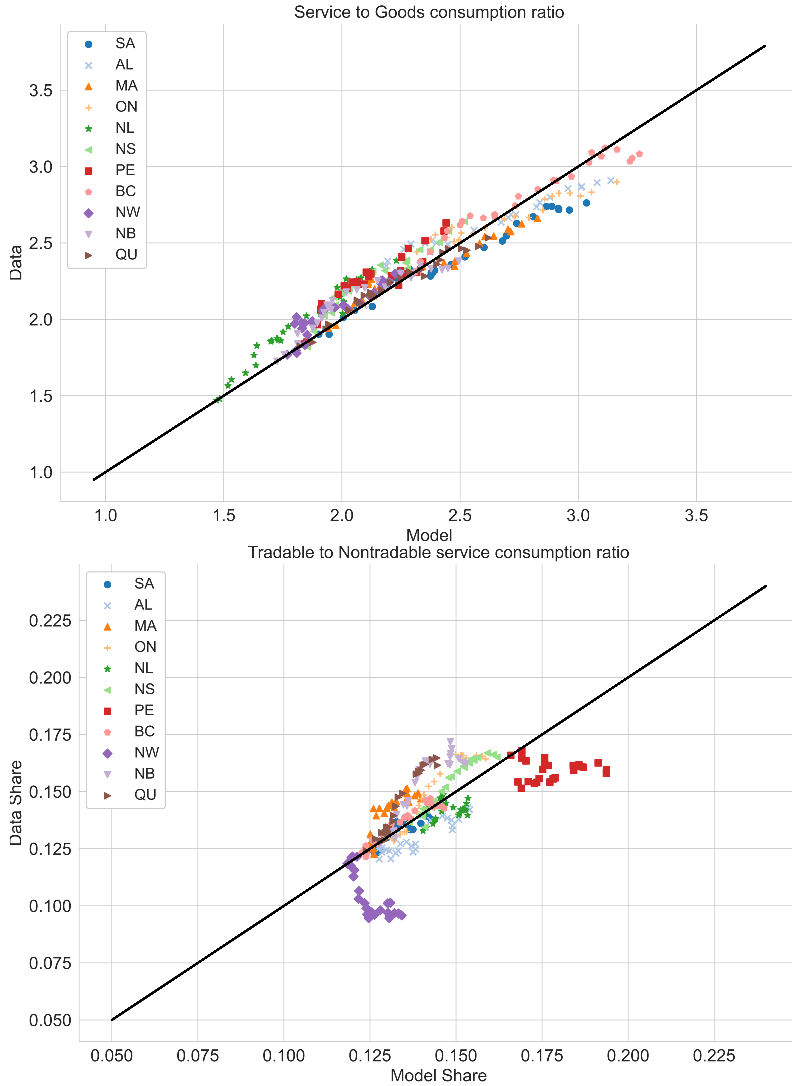

FIGURE 8 – Model fit for consumption ratio

We check the robustness of calibration by plotting the model fit for untargeted moments: sectoral prices. We make it in following steps: (i) We compute the construct nominal and real consumption for aggregate service following strategy in appendix **??**. (ii)We take the oberved service price as ratio of nominal to real service consumption data. We make it comparable across sectors by adjusting the price level in CGDC Productivity database. (iii) We feed this constructed service data, along with the data-implied consumption expenditure share, into equation 4.1, 4.2 and 4.8. Given the calibrated preference parameters, we can impute the model-implied sectoral price each province. Figure 9 illustrates how well the calibrated model fits the sectoral prices data. The model-constructed sectoral prices achieves that goal well, especially for tradable services. The correlation between the sectoral in the model and in the data is 0.87, 0.96 and 0.79 for goods, tradable services and non-tradable services,

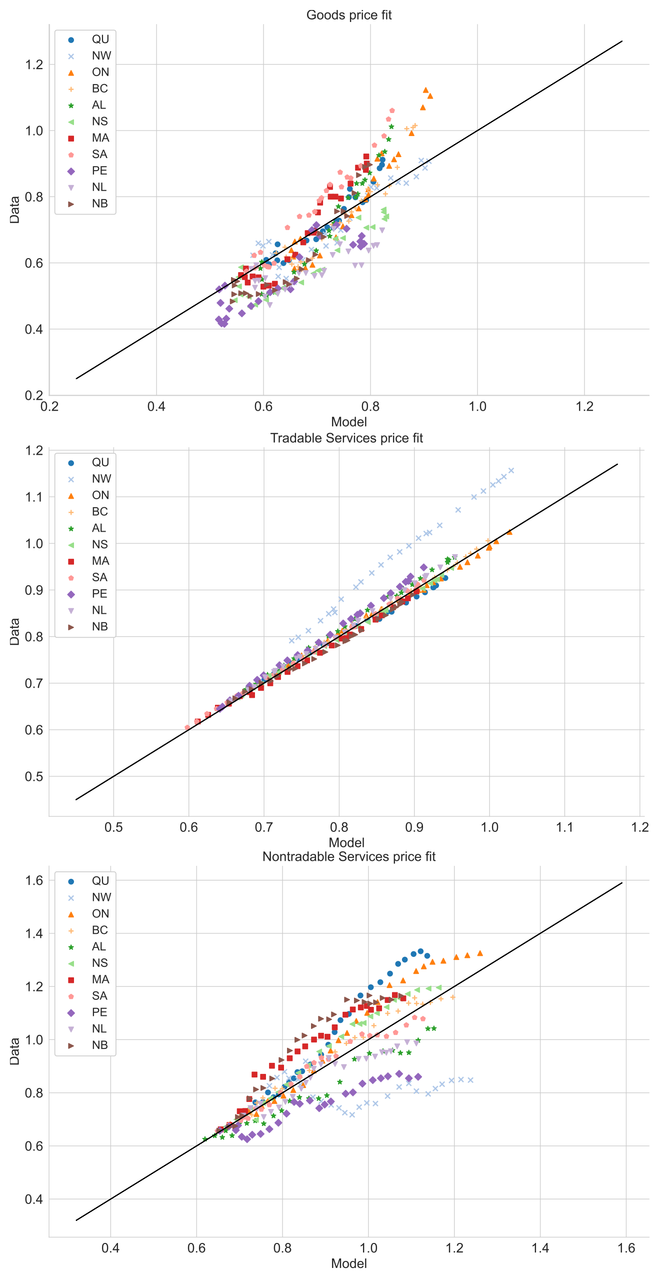

FIGURE 9 – Model fit for untargeted sectoral prices

respectively. The poor model fit for Northwest Territories (NW) in middle and lower panel is mainly due to its large deviation between the model and data nontradable-to-tradable consumption ratio. Overall, our model can closely match the moments that are not directly matched in the data.

4.2 Production parameters

We calibrate production parameters $\lambda_{ik}, \gamma_{ikn}$ using Canadian input-output tables. Similar to Rossi-Hansberg et al. (2019), production parameter values vary significantly across provinces. Therefore, we construct a 3×1 vector for λ_{ik} and 3×3 matrix for γ_{ikn} at a province-specific level through a straightforward calculation. Formally, λ_{ik} denotes the ratio of nominal value added to gross output and γ_{ikn} measures the share of sector n goods on intermediates inputs for the production in sector b. Due to the data limitation, provincial input-output tables are available only from 2004 to 2017 annually. We construct the time-invariant λ_{ik} and γ_{ikn} by taking average across these years for each province. This is feasible as the time-series variation within each province is negligible.

Average production parameters values as well as their maximum and minimum are reported in Table 2. There is huge heterogeneity on production shares across province, especially for λ_g, where New Brunswick uses goods intermediates more intensively, indicated by $\lambda_g = 0.27$. We find that those provinces with higher value added share in goods sector are generally have a higher λ_g than other services-intensive provinces. Furthermore, those goods-intensive provinces utilises more services to produce goods, with a higher $\gamma_{g,sm}$ than services-intensive provinces. As in Sposi (2019) and Lewis et al. (2020), goods production sources itself as intermediate more intensively while services production is more service-intensive, which holds for all provinces. Consistent with Simonovska and Waugh (2014), we set trade elasticity $\theta = 4$ for all sectors. $\eta = 4$ in our paper to ensure that Gamma function Γ evaluates at at positive domain.

4.3 Net export construction

With calibrated parameters, we can obtain sectoral consumption expenditure $P_{ik}C_{ik}$ for each province each year using equation 4.1 and 4.2. Next step is to construct the model-implied net export and value added through input-output linkage.

Calibration on sectoral net export requires consumption expenditure, input-output coefficients and the import expenditure share π_{ijk}, where $k \in \{g, sm\}$. We calibrate the trade costs such that the model and the data import shares are the same. Formally, we construct model-implied sectoral net export in following steps: (i) We compute import expenditure share π_{ijk} here using value added and bilateral trade flow data directly so that π_{ijk} exactly matches the data counterparts. Both international and inter-provincial trade flows are taken into account. (ii) We compute total absorption on each sector $P_{i,k}Q_{i,k}$ by jointly solving production equilibrium equations **??** and **??**. We utilise the calibrated sectoral consumption

Table 2 – Production parameters values

Production parameters		Avg	Max	Min
λ_g	Value-added share in gross output for Goods	0.41	0.52	0.27
λ_{sm}	for Tradable Services	0.62	0.65	0.59
λ_{sn}	for Nontradable Services	0.63	0.68	0.55
$\gamma_{g,g}$	Share of intermediate inputs sourced from Goods to Goods	0.71	0.82	0.60
$\gamma_{g,sm}$	from Trad. Services to Goods	0.28	0.37	0.17
$\gamma_{g,sn}$	from Nontrad. Services to Goods	0.01	0.03	0.009
$\gamma_{sm,g}$	from Goods to Trad. Services	0.26	0.33	0.21
$\gamma_{sm,sm}$	from Trad. Services to Trad. Services	0.69	0.74	0.63
$\gamma_{sm,sn}$	from Nontrad. Services to Trad. Services	0.04	0.05	0.04
$\gamma_{sn,g}$	from Goods to Nontrad. Services	0.29	0.33	0.25
$\gamma_{sn,sm}$	from Trad. Services to Nontrad. Services	0.43	0.49	0.40
$\gamma_{sn,sn}$	from Nontrad. Services to Nontrad. Services	0.28	0.32	0.22
θ	Trade elasticity	4.0		
η	Elasticity of substitution across goods within a sector	4.0		

expenditure in this step. (iii) Once we obtain sectoral absorption $P_{i,k}Q_{i,k}$ for all provinces, together with import share π_{ijk}, model-implied net export can be calculated from equation **??**.

Figure 10 depicts the model fit of sectoral net export share, which is measured by the ratio of sectoral net export to total value added for each province.[8] The reason for why benchmark model closely matches the net export share data is twofold. First, the import expenditure share π_{ijk} is calculated exactly from data by construction. Second, the calibrated model for sectoral consumption expenditure also fits well on its data moments.

4.4 Value added construction

As in Uy et al. (2013), we obtain model-implied sectoral value added using equation 4.10[9]. Ω is a matrix purely composed of provincial input-output coefficients $\lambda_{i,k}$ and $\gamma_{i,k,n}$. The involvement of exogenous production coefficients indicates the role of sectoral linkage in value added composition. Therefore, the equation specifies the value added as a matrix of sectoral expenditure $E_{i,k}$, net export $NX_{i,k}$ as well as the production parameters. Note that the sectoral expenditure $E_{i,k}$ refers to final absorption, which includes consumption expenditure $P_{ik}C_{ik}$, investment I_{ik} and government spending G_{ik}. The expenditure-based Canadian GDP

[8]Some data points outside the figure's interval are limited.

[9]Details of proof are shown in Appendix **??**

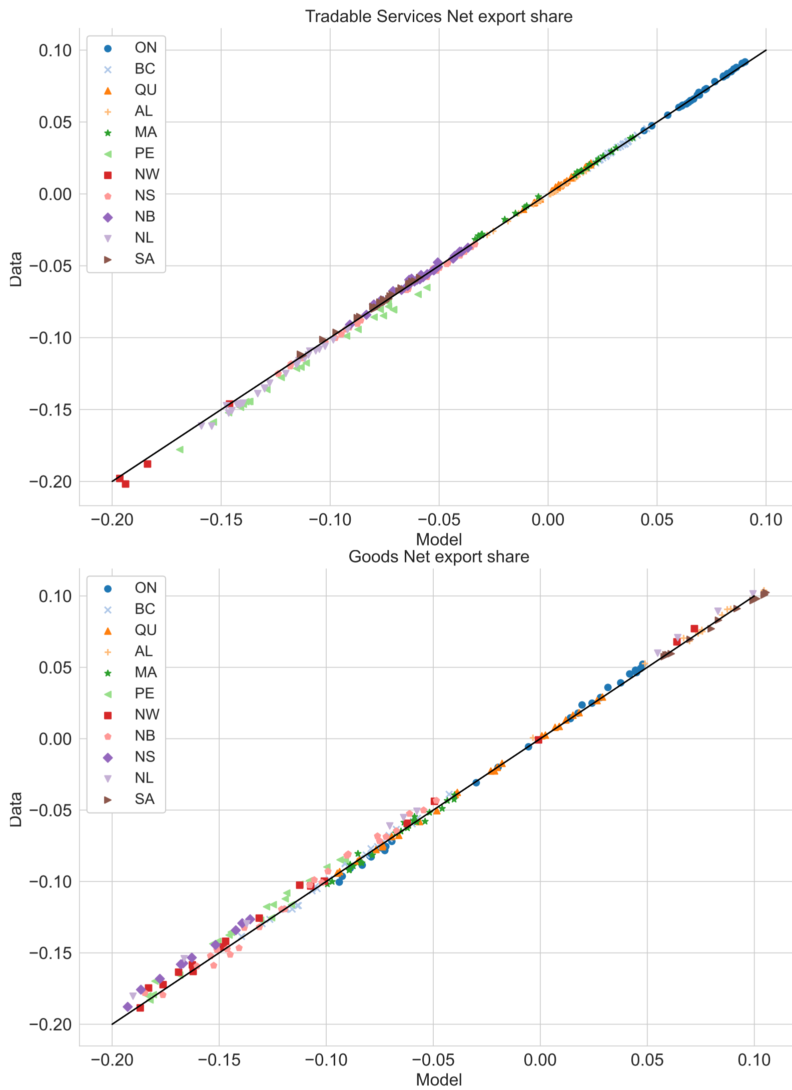

FIGURE 10 – Model fit for sectoral net export share

data from Statistics Canada provides us with the investment and government spending data at aggregate level. The classification of provincial input-output tables enable us to split the aggregate data into sectoral level annually. Cross-province variation is significant on the sectoral share of investment and government, but cross-time variation within province is very mild. The sectoral investment and government spending data, together with the calibrated consumption expenditure model, form into the model-implied sectoral expenditure $E_{i,k}$.[10] Hence, given $E_{i,k}$ and $NX_{i,k}$ constructed in model, we are able to calibrate model-implied sectoral VA for each province.

[10] We simply assume that I_{ik} and G_{ik} are unchanged in the benchmark and counterfactuals

$$\begin{bmatrix} VA_{i,g} \\ VA_{i,sm} \\ VA_{i,sn} \end{bmatrix} = \Omega^{-1} \begin{bmatrix} E_{i,g} \\ E_{i,sm} \\ E_{i,sn} \end{bmatrix} + \Omega^{-1} \begin{bmatrix} NX_{i,g} \\ NX_{i,sm} \\ 0 \end{bmatrix}, \tag{4.10}$$

where

$$E_{i,k} = P_{i,k}C_{i,k} + I_{i,k} + G_{i,k}, k \in \{g, sm, sn\}$$

The composition of value added indicates two channels that trade matters for structural change. First, expenditure channel: due to the selection effect of Ricardian model, trade openness enhances average productivity in tradable sectors and results in lower prices. Trade also rises real income for both regions in open economy. Given that price and income elasticities in our calibration are significantly different from 1, trade can impact sectoral expenditure share through both price and income effect. Second, net export channel: Trade can affect structual pattern of value added directly through net export channel. A province will experience a trade surplus in its comparative advantage sector. Therefore, workers will move from its comparative disadvantage sector to its comparative advantage sector and affect employment shares. In our model, by definition, sectoral employment shares exactly equal to value added shares.

Figure 11 specifies the correlation between the model-calibrated value added share and model-calibrated net export share for goods and tradable services. Similar to Figure 6 and 7, the positive correlation between value added and net export still holds in model both goods and tradable services.

We also plot the correlation between sectoral consumption share and net export share for both model and data. The upper panel in Figure 12 indicates that net export surplus in goods sector brings a negative impact to consumption share, thus hinders the transformation to goods. This is mainly contributed by two forces. First, income effect: the surplus in trade openness substantially increases aggregate income for Canada. As services are luxuries relative to goods ($\epsilon_g = 0.31$), demand for services rises and incurs the transformation from goods to services. This dominant income effect can also illustrate the rising pattern between tradable services consumption share and net export share in bottom panel. Second, price effect: Canada has a comparative advantage in trading services and disadvantage in goods. When Canada opens to trade, cheap goods from developing countries will dump into the domestic markets and result in lower relative price on goods. Then, the price effect channel would also imply a declining goods consumption share.

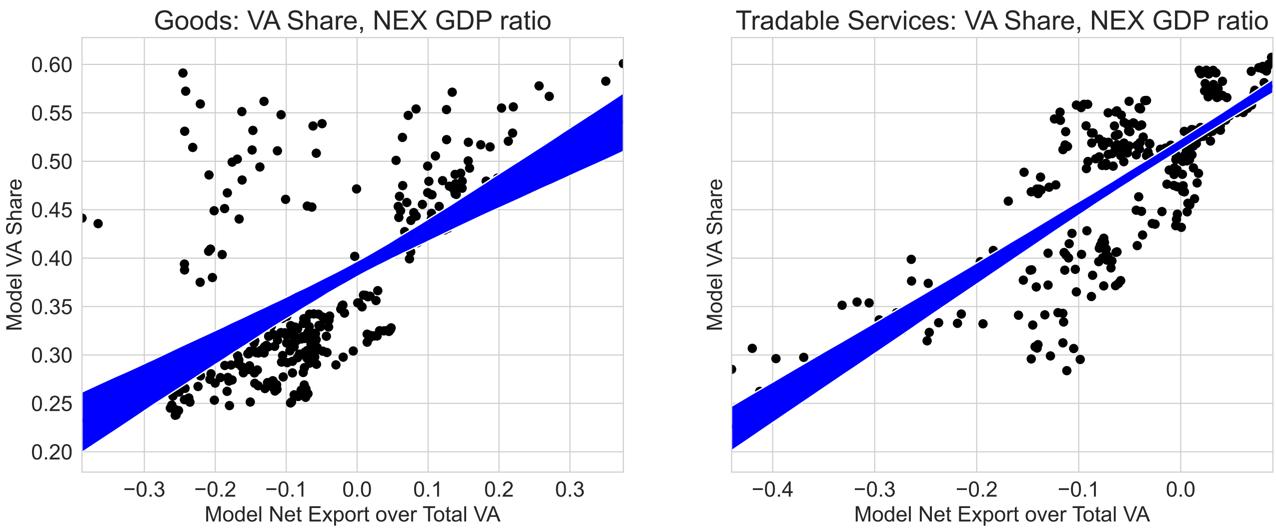

FIGURE 11 – The Correlation of the Model Value Added Share and Model Net Domestic/International Export

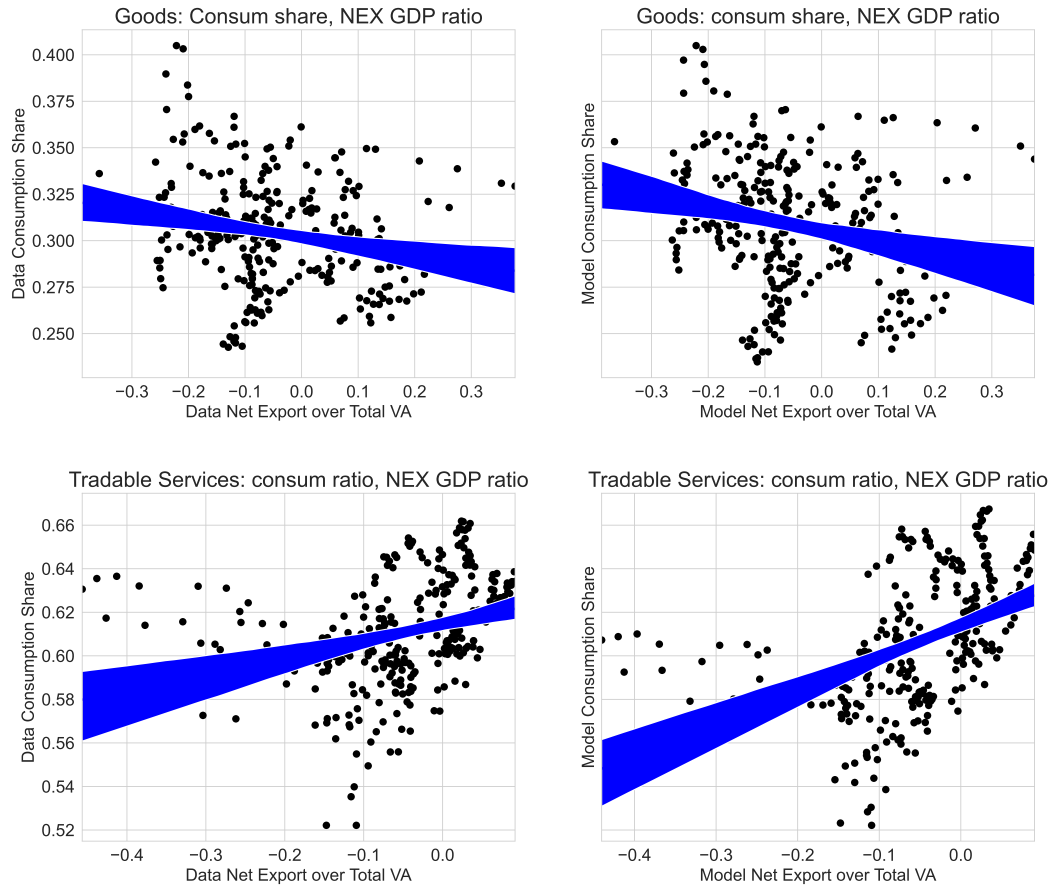

FIGURE 12 – Correlations between net export and VA & consumption ratio

5 Counterfactuals on regional specialization

In this section, we perform the following counterfactuals to examine how service trade shapes regional specialization. First, we shut down service trade and only allow for trade in goods as it is usually assumed in structural transformation models. We then assess the role of trade, productivities and non-homotheticity in the two economies: with service trade and without service trade (shutting down trade and shutting down changes in sectoral productivities). Second, we study the role played by domestic trade versus international trade. What role plays trade across regions in shaping Canada regional specialization and Canada overall sectoral composition.

5.1 Counterfatcual strategy

The counterfactual strategy is similar to Alvarez and Lucas (2007) and Lewis et al. (2020), which goes as follows: (i) Compute exogenous production efficiency T_{ik} and trade costs $\tau_{i,j,k}$ in benchmark using equation **??** and **??**.[11] Adjust trade cost values to 10^6 to shut down the corresponding trade flows. (ii) Give an initial guess to provincial wage w_i. (iii) Obtain the sectoral price P_{ik} and input cost v_{ik} by jointly solving equation 3.2 and 3.3 given that wage. (iv) Compute the per capita return from global portfolio ξ from equation 3.10. Note that values of ι_i are unchanged in the counterfactual. (v) Impute the counterfactual aggregate price P_i and aggregate real income C_i by jointly solving equation 3.8, 4.8 and 4.9. Then we can construct sectorl expenditure $E_{i.k}$ in the counterfactual. (vi) Compute sectoral real consumption C_{ik} for each province using equation 3.9, 4.1 and 4.1. (vii) Calculate import expenditure share π_{ijk} using equation 3.4. (viii) Compute the sectoral labor L_{ik}, gross output $P_{ik}Y_{ik}$, sectoral absorption $P_{ik}Q_{ik}$ and intermediate input usages $P_{ik}M_{ik}$ by combining production equilibrium conditions **??**, **??** and **??** in appendix. (ix) Utilize resource constraint **??** in appendix and compute the per-capita excess demand as $D_i = \left[\left(\sum_{k=g,sm,sn} P_{i,k}Y_{i,k} - \sum_{k=g,sm,sn} P_{i,k}Q_{i,k}\right) - (\iota_i w_i Li - \xi L_i)\right]/L_i$. (x) We slowly update the wage until the global market clears, $D_i = 0$. Specifically, we iterate provincial wage using $w_i^{'} = w_i + \delta D_i$, where we set $\delta = 0.01$ so that the wage vector w_i can slowly converge to the fixed point.

[11] Calibration strategy for T_{ik} and $\tau_{i,j,k}$ is described in appendix **??**, which is essentially same with Święcki (2017) and Sposi (2019)

5.2 The role of domestic service trade

Here we study the role of domestic services trade in driving Canadian regional structural transformation in service sector. By setting the domestic service trade cost to 10^6, we are able to keep the international services trade flows only. Trade flows for goods sector are as same as data. Table 3 summarizes the cross-sectional percentage change on different value added components by switching off domestic service trade. We compute the percentage change on aggregate real consumption C, relative price P_{sn}/P_{sm} and P_g/P_{sn}, tradable services net export share NX_{sm}/VA and value added share VA_{sm}/VA for each year each province respectively and report time-averaging results in each column. Hence, the first four columns imply income effect, price effect and net export channels; while the last column, value added share, reflect the aggregate effects through these three channels.

With the absence of domestic service trade, the real income shrinks for all Canadian provinces. This confirms Frankel and Romer (1999) and Irwin and Tervio (2002) that trade has a quantitatively large and robust, though only moderately statistically significant, positive effect on income. According to the income elasticity between goods and services, consumption expenditure will shift from services to goods. Note that, within service sector, nontradable services are luxuries relative to tradable services. Hence, reallocatons in economic activities will mostly occur in nontradable services, which mitigates the negative income effect on tradable services consumption expenditures. On the other hand, as household cannot get access to cheaper services products in other provinces, the relative price in column 2 and 3 will both decrease. Given the complementaity among three sectors, consumption share for tradable services raises via price effect. Therefore, the negative income force and positive price force counter each other and the net effect on tradable services consumption expenditure will depend on the larger force. In general, provinces with larger economic scale have a stable price, thus, smaller price effect force. Income effect then dominates and dampens consumption expenditure share in these wealthier provinces.

Figure 13 illustrates the average percentage change in tradable services value added share in no domestic service trade model. Taking Quebec as an example, by shutting down domestic service trade flows, the value added share in tradable services increase very slightly from 0-1%. In general, most Canadian provinces raise tradable service value added share with the absence of domestic service trade. This is mainly dominated by net export channel in column 4, the domestic tradable service net export over total value added. All provinces except Ontario are net importers for domestic service trade and the net export share to will grow from negative to zero by shutting domestic service trade flows. The gains in net export channels raises tradable service value added share for those importer provinces. Ontario, as

Table 3 – Percentage change (%) on different channels with absence of domestic service trade

Average change (%) over 1992-2017	No Domestic Service Trade C (1)	P_{sn}/P_{sm} (2)	P_g/P_{sm} (3)	NX_{sm}/VA (4)	VA_{sm}/VA (5)
Canadian Provinces					
Quebec	-6.3	-3.7	-3.7	1.6	0.4
Northwest Territories & Nunavut	-25.1	-16.7	-20.3	30.0	28.8
Ontario	-8.3	-2.3	-0.3	-5.7	-5.6
British Columbia	-6.3	-3.7	-3.6	1.6	0.3
Alberta	-7.7	-4.8	-4.9	3.4	2.6
Nova Scotia	-6.1	-6.5	-8.5	9.5	7.1
Manitoba	-12.2	-6.7	-6.1	1.3	-0.9
Saskatchewan	-9.6	-8.9	-10.4	12.1	14.6
Prince Edward Island	-8.6	-10.1	-12.9	15.3	13.7
Newfoundland and Labrador	-7.0	-9.4	-12.1	15.3	24.4
New Brunswick	-9.0	-8.4	-10.4	10.9	8.1

Notes: Each column reports the average percentage change for no domestic service trade model over 1992-2017 for each province by comparing with benchmark.

the only net exporter in domestic service trade, will behave in opposite direction. The effect from consumption expenditure channel only takes limited role given that income effect and price effect offset each other.

5.3 The role of international service trade

We further explore the role of international service trade by shutting down international service trade flows only. The effect on real income, relative price, net export and value added are shown in table 4. Similar to table 3, prohibition in international service trade dampens real income C in column 1 and results in negative income effect on tradable services consumption expenditure for all provinces. Higher tradable services price lowers down the relative price and brings about a positive price effect due to the complementarity. Compared with the absent domestic service trade counterpart, absence of international service trade

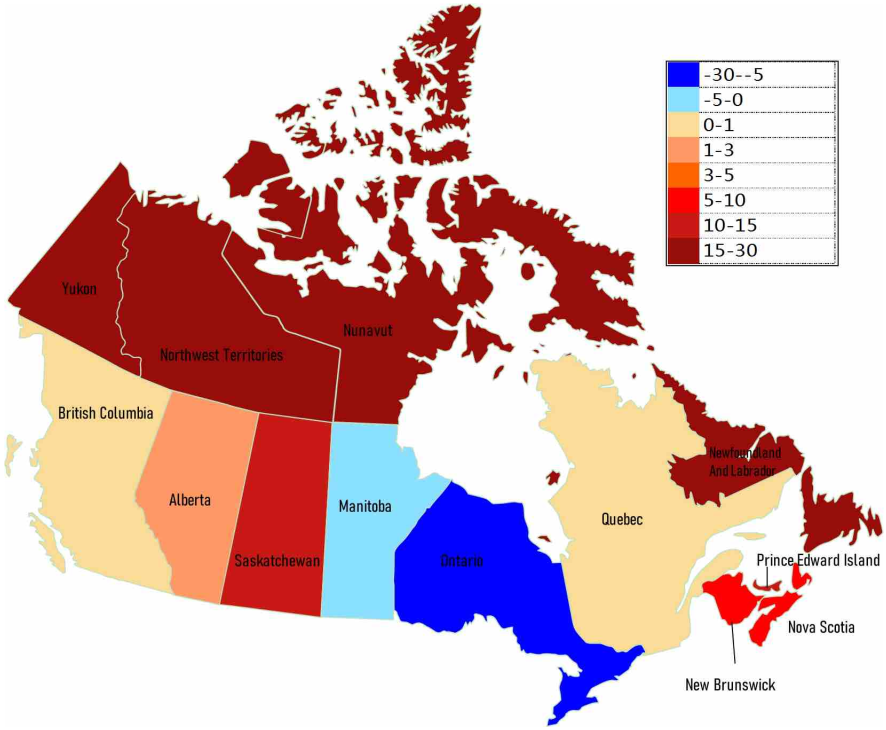

Figure 13 – Average percentage change (%) in tradable service VA share with absent domestic service trade

triggers milder changes in both real income and relative price. The main reason is that international trade only accounts for approximately 30% of total service trade volume. Given the strong regional specialization pattern with Canada and lower domestic trade cost relative to international one, goods-intensive provinces (i.e. Northwest Territories) can simply import services from services-intensive provinces (i.e. Ontario, Quebec). Hence, international service trade only takes a smaller role in affecting the relative prices.

As the force from price effect becomes much weaker, income effect outweighs and dominates in shaping the tradable services consumption expenditure. Hence, all Canadian provinces shifts economic activities away from tradable services sector and leads to a lower consumption expenditure share. Furthermore, contrast to the case of domestic service trade, all Canadian provinces gain trade surplus from international service trade. By switching off the international service trade flows, this time, the service net export share drops from positive to zero. Therefore, both consumption expenditure channel and net export channel generate negative effects and tradable services value added share falls for all provinces, shown in Figure 14. For provinces with higher international service export to value added ratio (i.e. Saskatchewan, New Brunswick), decrease in tradable services value added share is also stronger. On other hand, the reduction in value added in northern Canada is mainly

Table 4 – Percentage change (%) on different channels with absence of international service trade

Mean change (%) over 1992-2017	No International Service Trade				
	C (1)	P_{sn}/P_{sm} (2)	P_g/P_{sm} (3)	NX_{sm}/VA (4)	VA_{sm}/VA (5)
Canadian Provinces					
Quebec	-5.6	-1.9	-0.9	-2.2	-3.7
Northwest Territories & Nunavut	-7.0	-1.6	-1.2	-0.5	-7.6
Ontario	-6.6	-2.5	-1.6	-1.5	-2.6
British Columbia	-6.7	-1.8	-0.3	-4.7	-5.0
Alberta	-5.4	-1.5	-0.8	-2.4	-4.8
Nova Scotia	-5.3	-1.5	-0.2	-2.3	-3.5
Manitoba	-5.4	-1.8	-0.9	-2.2	-3.6
Saskatchewan	-6.0	-1.6	-0.8	-4.4	-8.7
Prince Edward Island	-5.1	-1.4	-0.1	-4.3	-5.2
Newfoundland and Labrador	-4.3	-1.2	-0.5	-2.5	-7.0
New Brunswick	-6.8	-1.8	0.1	-5.1	-5.8

Notes: Each column reports the average percentage change for no international service trade model over 1992-2017 for each province by comparing with benchmark.

attributed to the shrunk real income through consumption expenditure channel. However, in general, changes in tradable services value added shares with the absence of international service trade are much more evenly distributed than those in the domestic case.

5.4 The role of service trade

We do additional exercise by switching off both domestic and international service trade flows, which enables us to find the role of aggregate service trade. Table 5 documents the aggregate service trade effect on different channels. The real aggregate consumption C and relative price P_g/P_{sm} and P_{sn}/P_{sm} both substantially decrease, given that domestic and international service trade affects these consumption expenditure channels in same direction. The price effect and income effect cancel each other out, leaving tradable services consumption expenditure shares ambiguous across provinces. On the other hand, the service net

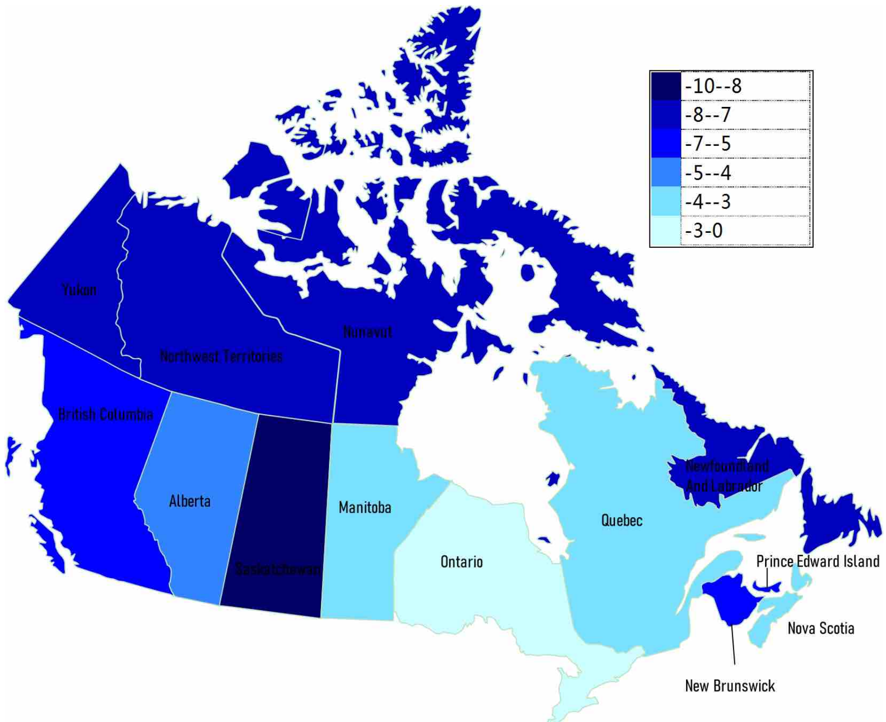

FIGURE 14 – Average percentage change (%) in tradable service VA share with absent international service trade

export share in column 4 is measured as the sum of both domestic and international service net export divided total value added. Therefore, for all provinces except Ontario, the signs for net export share depend on whether gains in international trade surplus can outweigh the loss in domestic service trade.

Figure 15 illustrates how service trade impacts value added share pattern across Canadian provinces. By ignoring service trade, tradable services value added share reduces in those services-intensive provinces (i.e. Ontario and British Columbia), while it rises in goods-intensive provinces (i.e. Northwest Territories, Nunavut, Newfoundland and Labrador). We can explain the heterogeneity in regional specialization pattern from both net export and consumption expenditure channel. For those services-intensive provinces, the trade-induced labor allocation substantially mitigates as those workers producing services for other regions are no longer needed. This results in labor in services-intensive provinces moving back to goods sector and affecting value added share via net export channel. Meanwhile, restricting on service trade dampens the real income for both service-intensive and goods-intensive provinces. Given that tradable services are luxuries relative to goods, the reduction in real income shifts consumption demand from tradable services to goods. Both two channels will decrease the tradable service value added share in services-intensive provinces. On the other

TABLE 5 – Percentage change (%) on different channels with absence of service trade

Mean change (%) over 1992-2017	No Service Trade C (1)	P_{sn}/P_{sm} (2)	P_g/P_{sm} (3)	NX_{sm}/VA (4)	VA_{sm}/VA (5)
Canadian Provinces					
Quebec	-11.4	-5.8	-5.2	-0.7	-2.0
Northwest Territories & Nunavut	-20.2	-21.3	-28.5	29.5	59.5
Ontario	-15.6	-4.8	-1.5	-7.1	-9.8
British Columbia	-13.1	-5.5	-3.9	-3.1	-5.1
Alberta	-12.4	-6.6	-6.4	0.9	0.2
Nova Scotia	-7.8	-8.4	-11.2	7.2	9.0
Manitoba	-16.7	-8.9	-7.9	-0.8	-2.5
Saskatchewan	-14.1	-11.2	-12.6	7.7	13.4
Prince Edward Island	-10.6	-11.9	-15.3	11.0	15.4
Newfoundland and Labrador	-9.4	-11.4	-14.5	12.9	27.7
New Brunswick	-13.2	-10.5	-12.1	5.9	7.0

Notes: Each column reports the average percentage change for no service trade model over 1992-2017 for each province by comparing with benchmark.

hand, those goods-intensive provinces have to reallocate labor resources to produce tradable services now, thus, tradable services employment share rises via net export channel. Furthermore, the marginal cost in producing tradable services is higher in goods-intensive provinces and is eventually reflected by higher tradable services prices. Both two forces drive up the value added share (employment share) in tradable services for goods-intensive provinces. Therefore, it is clear that service trade amplifies regional specialization substantially across Canadian provinces.

6 Drivers for structural transformation

In this section, we assess how price and income effect can shape the structural transformation through two channels: (i) consumption expenditure channel (ii) net export channel. Specifically, we fix either changes in relative price or real income and study how consump-

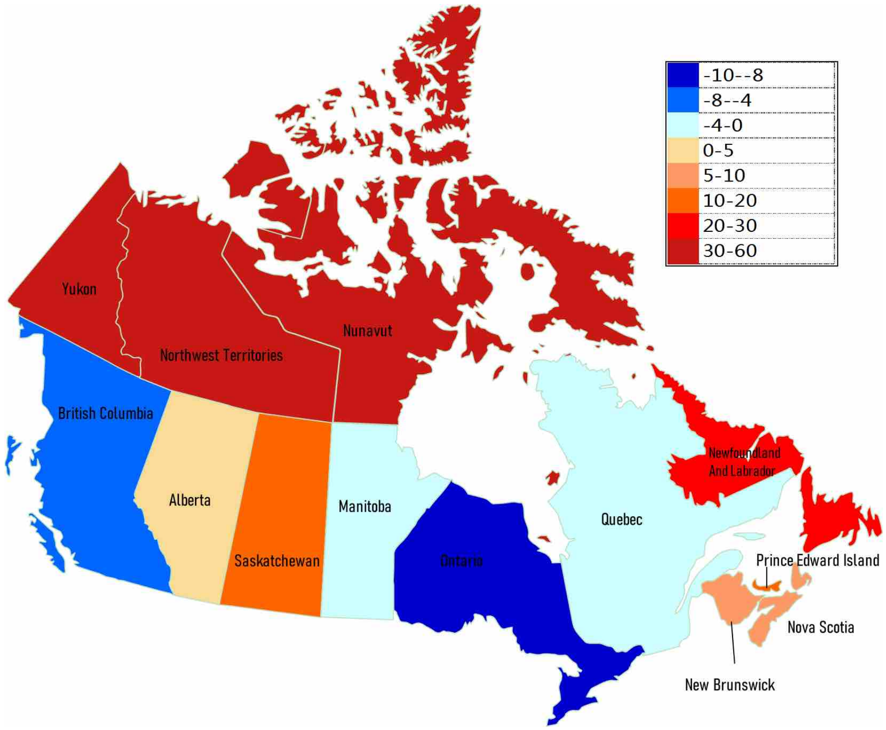

FIGURE 15 – Average percentage change (%) in tradable service VA share with absent aggregate service trade

tion expenditure and net export channels changes in response to the shock. In the first case, we fix the real income C and Table 6 summarized the percentage changes in both channels and value added shares across sectors. [12] Figure 16 shows how real income shape the structural transformation through consumption expenditure channel and net export channel respectively. We only switch on one channel for each exercise.

We then do a similar counterfactual for price effect by fixing the relative price to initial year and results are reported in Table 7.[13] Figure 17 depicts how relative price changes contribute to the structural transformation through consumption expenditure channel and net export channel respectively. Likewise, we further decompose net export channel into domestic and international net export. Figure 18 and Figure 19 illustrates the contribution on value added transformation through two channels with the international service trade only. On the other hand, Figure 20 and Figure 21 keep domestic service trade only and plot the change in structural transformation through two channels. Table 8 reports the structural transformation for price and income effect in models with open trade, international trade

[12] **??**, **??**, **??** and **??** in Appendix **??** plot the income effect on consumption expenditure channels and net export channel at provincial level.

[13] **??**, **??**, **??** and **??** in Appendix **??** show the price effect on consumption expenditure channels and net export channel at provincial level.

TABLE 6 – Structural Transformation by fixing C

1992-2017		Consumption Expenditure share growth			Average Net export over GDP		Value-added share growth		
Percentage change(%)		Goods	Trad. S.	Nontrad. S.	Services	Goods	Goods	Trad. S.	Nontrad. S.
Quebec	Benchmark	-22.0	10.0	28.3	0.7	-3.3	-13.5	8.3	4.3
	Fix C	-1.0	-0.8	11.6	1.3	-3.8	-6.3	4.0	1.4
Northwest Territories & Nunavut	Benchmark	-14.7	6.8	21.0	-28.6	-15.8	16.9	-23.6	8.4
	Fix C	2.6	-2.5	7.3	-28.4	-16.5	21.0	-27.8	6.3
Ontario	Benchmark	-25.6	9.5	33.0	7.1	-1.7	-22.1	12.0	4.5
	Fix C	-1.9	-1.0	15.6	7.7	-2.4	-15.2	8.8	1.0
British Columbia	Benchmark	-22.7	7.5	29.4	3.1	-9.2	-8.0	3.9	0.7
	Fix C	-0.7	-1.4	14.6	3.7	-9.8	-0.2	0.7	-2.7
Alberta	Benchmark	-25.2	9.3	33.9	-0.8	11.4	8.6	-5.6	-6.0
	Fix C	-1.8	-1.1	16.6	-0.8	11.4	14.6	-9.8	-9.6
Nova Scotia	Benchmark	-20.5	9.0	29.2	-7.0	-21.2	-11.7	4.2	5.2
	Fix C	0.7	-2.1	12.1	-5.7	-22.0	-1.7	0.3	1.6
Manitoba	Benchmark	-23.1	10.5	23.5	0.6	-6.8	-0.9	-1.4	6.3
	Fix C	-1.4	-0.1	7.6	1.2	-7.3	7.1	-5.5	3.7
Saskatchewan	Benchmark	-28.1	13.0	29.2	-7.9	12.2	7.3	-1.3	-17.5
	Fix C	-1.3	-0.4	8.8	-7.3	11.6	13.4	-6.7	-20.8
Prince Edward Island	Benchmark	-17.4	6.9	24.8	-10.4	-14.3	-12.4	2.9	12.1
	Fix C	1.2	-2.5	10.3	-9.6	-15.1	-4.6	-0.7	9.1
Newfoundland and Labrador	Benchmark	-23.6	14.7	25.9	-12.5	1.8	33.6	-17.2	-26.0
	Fix C	-0.7	-0.2	5.2	-11.9	1.4	41.7	-23.1	-28.9
New Brunswick	Benchmark	-22.0	10.5	30.2	-6.0	-11.4	-14.8	10.1	-0.5
	Fix C	1.1	-2.1	8.1	-4.6	-12.5	-6.8	6.1	-4.5
Canada	Benchmark	-24.4	9.7	31.2	2.4	-1.0	-8.4	5.5	0.0
	Fix C	-1.8	-0.8	14.2	2.9	-1.5	-3.6	3.0	-2.5

Notes: The table illustrates the structural transformation on income effect via consumption expenditure channel and net export channel and how it reflects on value added share. Each column computes the percentage change in different channels from 1992 to 2017 across provinces.

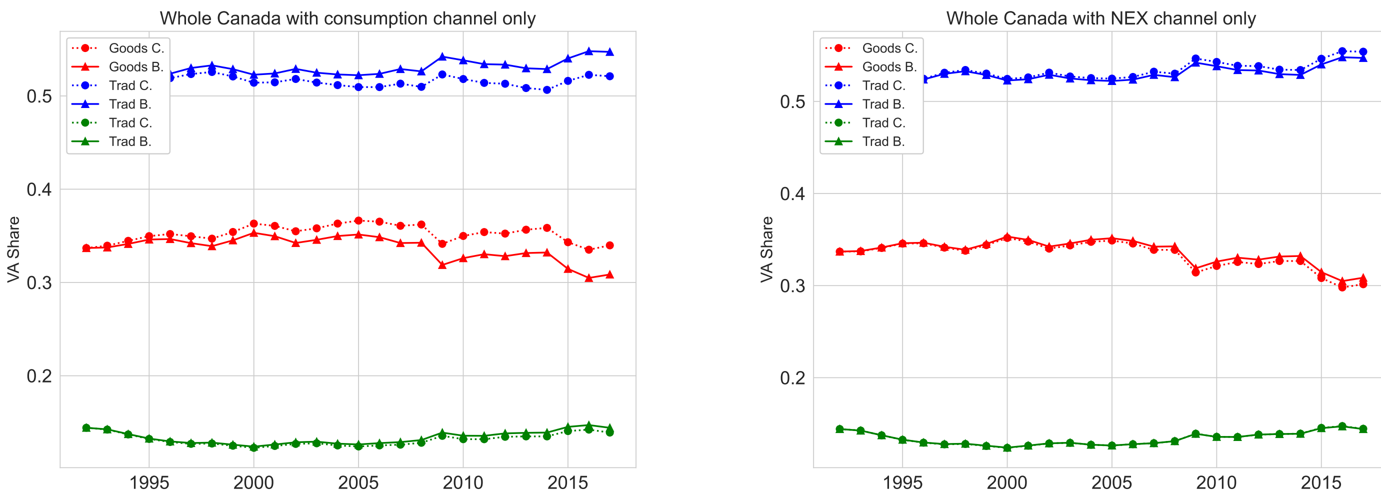

FIGURE 16 – Structural Transformation through Consumption Expenditure channel/Net export channel only: Fix C

only and domestic trade only respectively.

7 Conclusion

In this paper, we study how service trade affects structural transformation and regional patterns of specialization. We document that i) inter-provincial and international trade of services has significantly increased between 1992-2017; ii) inter-provincial trade is larger in services compared to goods; iii) structural transformation occurs from goods to tradable services, specially in tradable service intensive provinces; and iv) tradable services (and goods) value-added shares strongly correlate with sectoral net exports.

We then use a spatial model to study how international and domestic trade of services amplifies or dampens the structural transformation of the whole Canadian economy over 1992 – 2017. Our results indicate that service trade, domestic and international, amplifies regional specialization and increases the share of tradable service sector in Canada. Specifically, (service) trade drives the 55% (40%) of the tradable services value added shares increase in Canada. We also observe the huge heterogeneity on regional specialization across Canada provinces. Even though bulk of structural transformation occurs from goods to tradable services sectors at country level, it occurs mostly in provinces specialized in tradable services. Other goods-intensive provinces records an opposite regional specialization, with economic activities moving from tradable services to goods. Overall, our results imply that an open

TABLE 7 – Structural Transformation by fixing Relative Price

1992-2017		Consumption Expenditure share growth			Average Net export over GDP		Value-added share growth		
Percentage change(%)		Goods	Trad. S.	Nontrad. S.	Services	Goods	Goods	Trad. S.	Nontrad. S.
Quebec	Benchmark	-22.0	10.0	28.3	0.7	-3.3	-13.5	8.3	4.3
	Fix P	-21.1	11.1	15.2	-1.0	-1.6	-9.9	10.5	-10.7
Northwest Territories & Nunavut	Benchmark	-14.7	6.8	21.0	-28.6	-15.8	16.9	-23.6	8.4
	Fix P	-17.0	9.3	12.5	-32.7	-12.1	13.5	-14.9	-4.1
Ontario	Benchmark	-25.6	9.5	33.0	7.1	-1.7	-22.1	12.0	4.5
	Fix P	-23.9	10.9	15.4	3.6	1.8	-12.2	10.1	-11.5
British Columbia	Benchmark	-22.7	7.5	29.4	3.1	-9.2	-8.0	3.9	0.7
	Fix P	-22.1	9.2	13.1	0.9	-6.9	-5.2	5.7	-12.6
Alberta	Benchmark	-25.2	9.3	33.9	-0.8	11.4	8.6	-5.6	-6.0
	Fix P	-23.7	10.8	15.2	-2.7	13.2	7.1	-1.1	-18.5
Nova Scotia	Benchmark	-20.5	9.0	29.2	-7.0	-21.2	-11.7	4.2	5.2
	Fix P	-21.0	11.2	15.3	-11.9	-15.8	3.6	2.7	-12.9
Manitoba	Benchmark	-23.1	10.5	23.5	0.6	-6.8	-0.9	-1.4	6.3
	Fix P	-21.9	10.8	15.0	-2.6	-3.5	4.8	0.3	-10.5
Saskatchewan	Benchmark	-28.1	13.0	29.2	-7.9	12.2	7.3	-1.3	-17.5
	Fix P	-27.0	13.6	19.0	-9.9	14.1	6.9	3.4	-28.4
Prince Edward Island	Benchmark	-17.4	6.9	24.8	-10.4	-14.3	-12.4	2.9	12.1
	Fix P	-18.5	9.6	13.0	-15.2	-9.5	3.9	0.1	-6.3
Newfoundland and Labrador	Benchmark	-23.6	14.7	25.9	-12.5	1.8	33.6	-17.2	-26.0
	Fix P	-22.9	15.0	19.9	-12.8	2.2	27.3	-7.2	-34.5
New Brunswick	Benchmark	-22.0	10.5	30.2	-6.0	-11.4	-14.8	10.1	-0.5
	Fix P	-23.0	12.8	17.4	-15.8	-1.3	17.4	-5.8	-17.7
Canada	Benchmark	-24.4	9.7	31.2	2.4	-1.0	-8.4	5.5	0.0
	Fix P	-23.3	11.1	15.5	-0.3	1.7	-5.0	7.2	-13.9

Notes: The table illustrates the structural transformation on price effect via consumption expenditure channel and net export channel and how it reflects on value added share. Each column computes the percentage change in different channels from 1992 to 2017 across provinces.

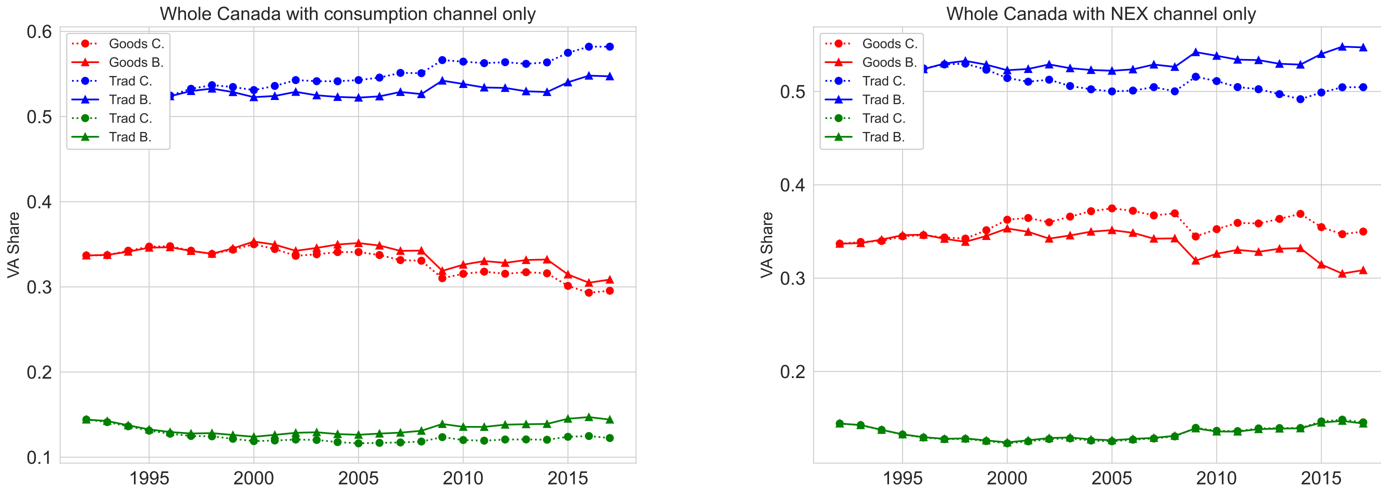

FIGURE 17 – Structural Transformation through Consumption Expenditure channel/Net export channel only: Fix Relative Price

economy structural transformation model that does not take into account the service trade can generate misleading predictions of sectoral change patterns.

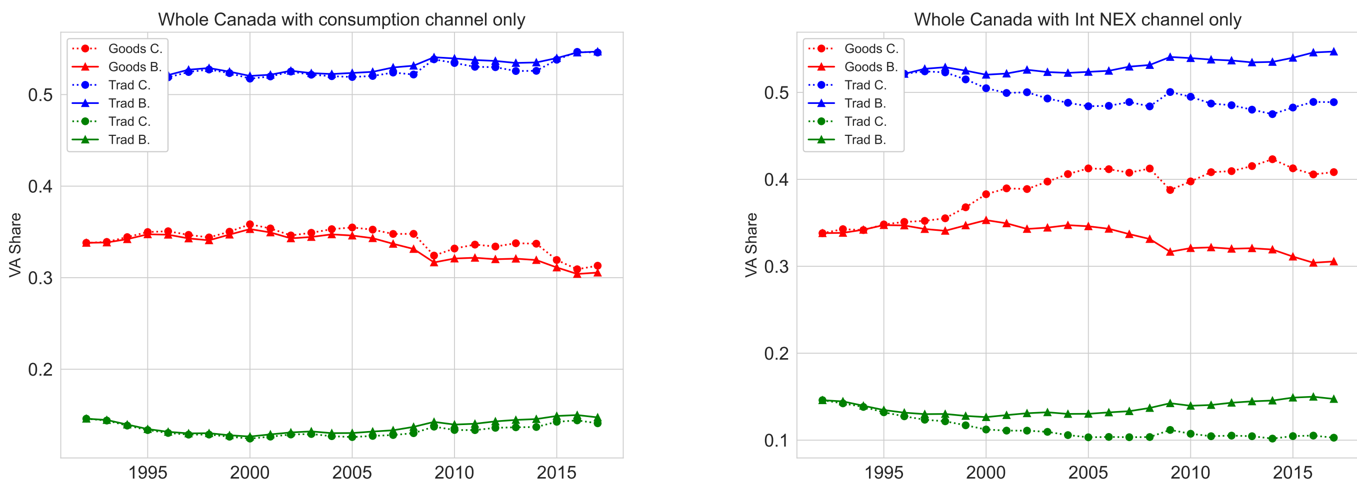

FIGURE 18 – Structural Transformation with international trade only: Fix Relative Price

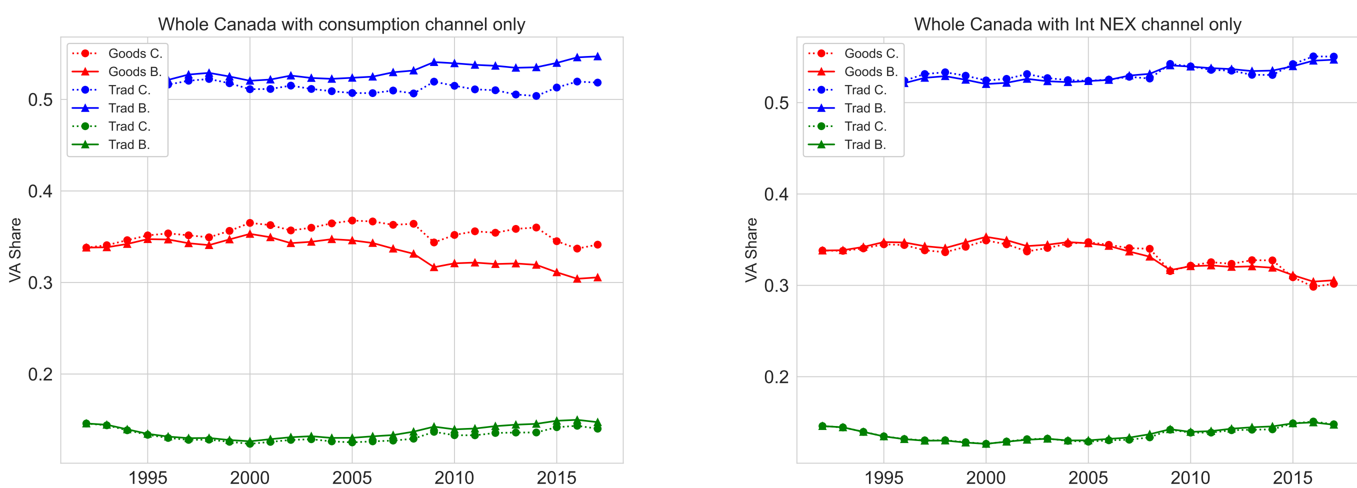

FIGURE 19 – Structural Transformation with international trade only: Fix C

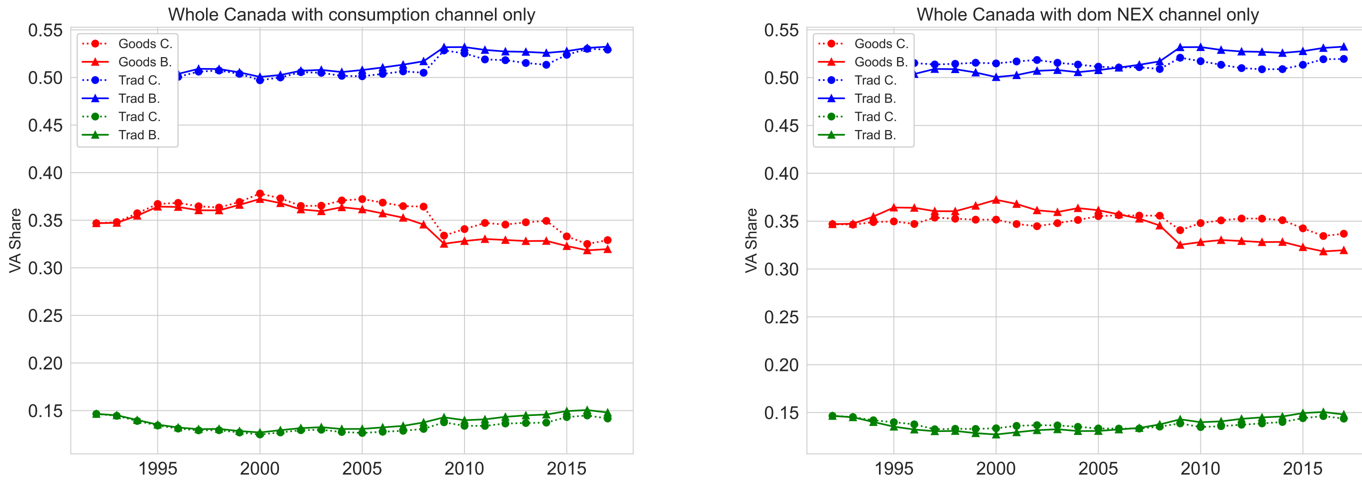

FIGURE 20 – Structural Transformation with domestic trade only: Fix Relative Price

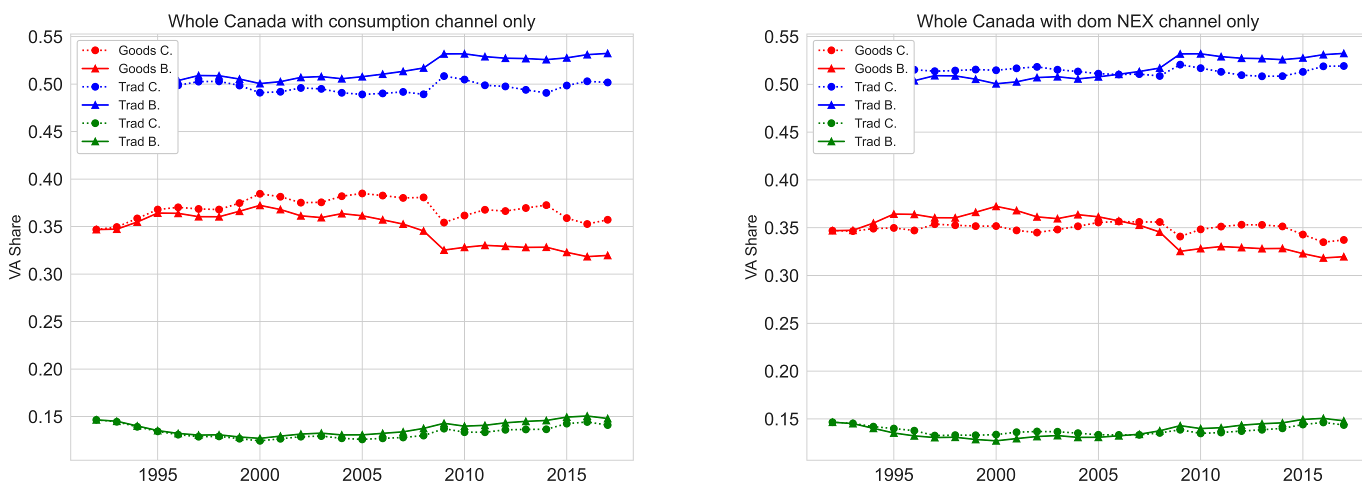

FIGURE 21 – Structural Transformation with domestic trade only: Fix C

Table 8 – Price versus Income Effects on different channels in Canada

Channels		Price effect: Consumption expenditure (1)	Price effect: Net export (2)	Income effect: Consumption expenditure (3)	Income effect: Net export (4)
		Panel A: Benchmark			
Goods	% Change	-12.3	3.9	0.9	-10.5
	Diff from B.	-3.9	12.3	9.3	-2.1
Tradable services	% Change	12.2	-2.7	0.4	6.8
	Diff from B.	6.7	-8.2	-5.0	1.3
Nontradable services	% Change	-15.0	0.9	-3.6	0.2
	Diff from B.	-15.0	0.9	-3.5	0.2
		Panel B: International trade only			
Goods	% Change	-7.4	21.5	1.0	-11.2
	Diff from Int. model	2.2	31.2	10.6	-1.5
Tradable services	% Change	5.8	-5.2	0.5	6.6
	Diff from Int. model	-0.2	-11.2	-5.5	0.5
Nontradable services	% Change	-3.4	-28.9	-3.9	1.3
	Diff from Int. model	-4.4	-29.9	-4.9	0.3
		Panel C: Domestic trade only			
Goods	% Change	-5.1	-2.9	3.0	-2.8
	Diff from Dom. model	2.7	5.0	10.8	5.1
Tradable services	% Change	4.5	2.5	-0.9	2.5
	Diff from Dom. model	-0.6	-2.5	-6.0	-2.6
Nontradable services	% Change	-3.3	-2.0	-3.8	-2.0
	Diff from Dom. model	-4.3	-3.0	-4.7	-3.0

Notes: We calculate the the percentage change in sectoral value-added share from 1992 to 2017 at whole country level for both consumption expenditure channels and net export channels. Panel A, Panel B and Panel C report the percentage change in in sectoral value-added share for the counterfactual and the difference from the benchmark model, only international trade model and only domestic trade model respectively.

References

Alvarez, Fernando and Robert Jr. Lucas, "General equilibrium analysis of the Eaton-Kortum model of international trade," *Journal of Monetary Economics*, September 2007, *54* (6), 1726–1768.

Buera, Francisco J. and Joseph P. Kaboski, "The Rise of the Service Economy," *American Economic Review*, May 2012, *102* (6), 2540–69.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, 11 2014, *82* (1), 1–44.

_ , _ , Esteban Rossi-Hansberg, and Pierre-Daniel Sarte, "The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy," *The Review of Economic Studies*, 12 2017, *85* (4), 2042–2096.

Coşar, A. Kerem and Pablo D. Fajgelbaum, "Internal Geography, International Trade, and Regional Specialization," *American Economic Journal: Microeconomics*, February 2016, *8* (1), 24–56.

Comin, Diego, Danial Lashkari, and MartÃ Mestieri, "Structural Change With LongâRun Income and Price Effects," *Econometrica*, January 2021, *89* (1), 311–374.

Cravino, Javier and Sebastian Sotelo, "Trade-Induced Structural Change and the Skill Premium," *American Economic Journal: Macroeconomics*, July 2019, *11* (3), 289–326.

Duarte, Margarida and Diego Restuccia, "Relative Prices and Sectoral Productivity," *Journal of the European Economic Association*, 05 2019, *18* (3), 1400–1443.

Duernecker, Georg, Berthold Herrendorf, and Ákos Valentini, "Structural Change within the Services Sector and the Future of Cost Disease," *Working paper*, 10 2019.

Eaton, Jonathan and Samuel Kortum, "Technology, Geography, and Trade," *Econometrica*, 2002, *70* (5), 1741–1779.

Echevarria, Cristina, "Agricultural development vs. industrialization: Effects of trade," *Canadian Journal of Economics*, 1995, pp. 631–647.

Eckert, Fabian, "Growing Apart: Tradable Services and the Fragmentation of the US Economy," *Working Paper*, 2019.

_ and Michael Peters, "Spatial Structural Change," *Working Paper*, 2018.

Fajgelbaum, Pablo and Stephen J. Redding, "Trade, Structural Transformation and Development: Evidence from Argentina 1869-1914," *Working Paper*, 2018.

Frankel, Jeffrey A. and David H. Romer, "Does Trade Cause Growth?," *American Economic Review*, June 1999, *89* (3), 379–399.

Herrendorf, Berthold, Richard Rogerson, and Ákos Valentinyi, "Growth and Structural Transformation," *Handbook of Economic Growth*, 2014.

Irwin, Douglas A. and Marko Tervio, "Does trade raise income?: Evidence from the twentieth century," *Journal of International Economics*, 2002, *58* (1), 1–18.

Lewis, Logan, Ryan Monarch, Michael Sposi, and Jing Zhang, "Structural change and global trade," 2020.

Matsuyama, Kiminori, "Agricultural productivity, comparative advantage, and economic growth," *Journal of economic theory*, 1992, *58* (2), 317–334.

Rossi-Hansberg, Esteban, Pierre-Daniel Sarte, and Felipe Schwartzman, "Cognitive Hubs and Spatial Redistribution," September 2019, (26267).

Simonovska, Ina and Michael Waugh, "The elasticity of trade: Estimates and evidence," *Journal of International Economics*, 2014, *92* (1), 34–50.

Sposi, Michael, "Evolving comparative advantage, sectoral linkages, and structural change," *Journal of Monetary Economics*, 2019, *103*, 75 – 87.

Święcki, Tomasz, "Determinants of structural change," *Review of Economic Dynamics*, 2017, *24*, 95–131.

Uy, Timothy, Kei-Mu Yi, and Jing Zhang, "Structural change in an open economy," *Journal of Monetary Economics*, 2013, *60* (6), 667–682.