

THE CONTRIBUTION OF REGION-SPECIFIC SHOCKS
TO AGGREGATE FLUCTUATIONS: EVIDENCE FROM
THE LOCAL HOUSING MARKETS IN CANADA

by

Wenbo Zhu

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DALHOUSIE UNIVERSITY
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Abstract

This thesis investigates the contribution of productivity shocks at different aggregation levels to residential investment and relative house prices in ten local housing markets in Canada from 1986 to 2007. It has two major conclusions. First, while in BC, Ontario, and four Atlantic Provinces, residential investment is more likely to be affected by aggregate shocks, in Quebec and three Prairie Provinces, residential investment is less responsive to aggregate shocks, and more likely to be affected by region-specific shocks. Second, relative house prices are much more variable than residential investment, and largely depend on region-specific factors.

List of Abbreviations Used

Seemingly Unrelated Regression Estimation (SURE)

Total Factor Productivity (TFP)

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Chapter 1

Introduction

The housing market has been evolving into an economically significant component of the modern macroeconomic market system for a long time. Especially with the help of the modern financial instruments, notably securitization, the influence of one local housing market on other markets can be formidable. The world-wide spread of the 2007 sub-prime crisis in the United States is a case in point. Conversely, local housing markets can also be affected by events taking place elsewhere in the economy.

Among several important characteristics of the housing market, the non-tradable nature of its service stands out: housing services cannot be sold or transferred from one local market to another. The housing service provided in Vancouver is not a relevant supply for the housing service demand in Toronto. To a large extent, this location-specific, non-tradable nature of housing services leads to a segmentation of local housing markets in different regions. As such, a local housing market may be more likely to be affected by regional events or shocks, such as exogenous natural disasters and local demand shocks.

At the same time, most of the inputs to the housing market are fairly mobile across regions. Construction equipment can be transported across regions. Even

labour is partly mobile within a country. Consequently, economic events or shocks coming from one local housing market may be transmitted to and have significant impact on another local housing market. As such, a local housing market may be affected by these aggregate events or shocks, and the segmentation of local housing markets may be compromised accordingly, leading to a partial segmentation of local housing markets. For example, a booming housing market in Alberta would attract construction workers, and therefore, companies in Manitoba might increase wages, which in turn affects both housing demand and supply in Manitoba.

Thus, both local economic events (region-specific shocks) and the aggregation of all economic events or shocks transmitted from elsewhere (aggregate shocks) will jointly influence the local housing market, and it is important to assess the independent contributions of these shocks to the behavior of the local housing market. From an economic policy standpoint, if local housing markets respond predominantly to region-specific shocks, then local policies would be more appropriate to influence and regulate local housing markets. By contrast, if local housing markets respond predominantly to aggregate shocks in a similar fashion, then federal-level policies would be appropriate. Yet, if local housing markets demonstrate different response patterns, the implementation of a federal policy might be counter-productive in some regions. Only when the aggregate shocks are dominant in every local housing market and all the local housing markets have the same response pattern, it is possible to rely on the federal policies or regional policy coordination.

Since both region-specific shocks and aggregate shocks may have impacts on local housing markets, an appropriate analytical framework should be able to account for both kinds of shocks, and allow them to interact with other relevant economic

factors. To this end, I adopt and modify the framework proposed by Glick and Rogoff (1995) and Iscan (2000), which distinguishes between country-specific shocks and international aggregate shocks.

This thesis focuses on Canadian local housing markets from 1986 to 2007. The basic analytical idea of this research is as follows. Each province in Canada is considered as a “small open economy,” which means each province is economically open to other provinces, yet not big enough to influence all the other provinces as a whole. In each province, there are two sectors: the housing service sector and the non-housing sector. The housing service sector invests in residential buildings and provides housing rental services, which is non-tradable. The non-housing sector produces a non-housing composite good, which could be consumed and invested across different provinces. All the inputs except labour (i.e. construction materials, machineries, etc.) in the housing service sector originate from the non-housing sector. Therefore, every sector in this multi-region economy are connected. The empirical analysis uses the seemingly unrelated regression estimation (SURE) method to capture these connections across provinces.

Previous empirical research on housing markets mostly uses data from the United States. This research finds that housing markets across different regions show significantly different cyclical behaviors. For example, Dokko et al. (1999) find that, in the late 1980s, prices in commercial housing markets across cities were not uniformly depressed following the burst of the real estate bubble in the United States. Edelstein and Tsang (2007) also demonstrate that four largest metropolitan statistical areas in California have different dynamic patterns in real rent and real housing investment during the 1988-2003 period.

There are relatively fewer empirical studies on Canadian housing markets. Most of the recent papers use time series techniques, which are different from the method adopted in this paper. In a recent paper, Allen et al. (2009) conclude that there is no evidence to support the existence of cointegration between the housing prices in seven major Canadian cities and that of the national level aggregation. Also, previous research is mostly about house prices. By contrast, this thesis focuses on both residential investment and *relative* house prices in different local housing markets in Canada from 1986 to 2007.

In addition, several papers focus on the national housing market, while others focus on local housing markets. For example, using quarterly data from 1963 to 1983, Topel and Rosen (1988) investigate the national residential housing market in the United States. On the other hand, Case and Mayor (1995) examine the local housing markets in eastern Massachusetts between 1982 and 1994. This thesis, however, focuses on comparing and contrasting the contributions of the productivity shocks originating from both the national level and the regional level to residential investment and relative house prices using data from local housing markets in Canada.

To briefly preview major conclusions of this paper, during the period from 1986 to 2007, while in BC, Ontario, and four Atlantic Provinces, residential investment is more likely to be affected by aggregate shocks, in Quebec and three Prairie Provinces, residential investment is less responsive to aggregate shocks, and more likely to be affected by region-specific shocks. Second, relative house prices are much more variable than residential investment, and relative house prices largely depend on region-specific factors.

The plan of this thesis is as follows. Chapter 2 constructs a theoretical framework to link region-specific shocks and aggregate shocks to residential investment and relative house prices. Chapter 3 takes the prediction of the theoretical framework as the starting point to develop a regression model, and discusses the results of the regression model. Chapter 4 concludes.

Chapter 2

The Theoretic Model

In order to provide a theoretical framework, in which both region-specific shocks and aggregate shocks can jointly interact with other important economic factors, this thesis considers a two-sector small open economy model. Many of the attributes of this model are inherited from Glick and Rogoff (1995) and Iscan (2000).

2.1 The Economic Environment of the Canadian Housing Market

Each province in Canada is treated as a “small open economy,” and the Canadian border is the boundary of these small economies. Each province has two sectors, the housing service sector and the non-housing sector. The housing service sector makes residential investment decisions by building new houses or refurbishing existing ones, and provides housing rental services to households. A representative household rents a house from the housing service sector. The non-housing sector, alternatively, provides a non-housing composite good, which could fulfill other needs in the economy. The housing rental service is non-tradable, while the non-housing good is tradable across

provinces. The inputs of residential investment, except labour, come from the non-housing sector and each province can also interact with each other by importing and exporting the non-housing traded good.

In the housing service sector of each province, the housing rental service provided is proportional to the existing housing stock:

$$Y_{t,j}^h = \eta H_{t,j}, \quad t = 1, \dots, T; \quad j = 1, \dots, J \quad (2.1.1)$$

where $Y_{t,j}^h$ is the housing rental service provided in province j at time t , and $H_{t,j}$ is the housing stock in province j at time t . $0 < \eta < 1$ measures the productivity of the housing stock. Hence, equation (2.1.1) can be viewed as the “production function” for the housing rental service.

While the housing stock can be increased by investment (construction), it also depreciates at a constant rate, δ , over time. So, the housing stock accumulation is:

$$H_{t+1,j} = I_{t,j}^h + (1 - \delta)H_{t,j}, \quad (2.1.2)$$

where $I_{t,j}^h$ is the residential investment in province j at time t , and $0 < \delta < 1$ is the constant depreciation rate in the housing stock accumulation.

The residential investment, $I_{t,j}^h$, takes the Cobb-Douglas function form:

$$I_{t,j}^h \equiv F(A_{t,j}, K_{t,j}, L_{t,j}) = A_{t,j} K_{t,j}^\alpha L_{t,j}^{1-\alpha}, \quad (2.1.3)$$

where $A_{t,j}$ is the total-factor productivity in residential investment in province j at time t , and $K_{t,j}$ is the capital input and $L_{t,j}$ is the labour input in residential investment, respectively. $0 < \alpha < 1$ is the capital share of residential investment.

Following the lead of Glick and Rogoff (1995) and Iscan (2000), I assume that the TFP in residential investment in each province could be decomposed into a region-specific (i.e. provincial) component and a national level aggregate component as $A_{t,j} = A_{t,j}^P A_{t,j}^F$. Also, the capital input, $K_{t,j}$, comes from the non-housing sector, and the labour input, $L_{t,j}$, is exogenous in this model.¹

As long as residential investment is optimized, the housing stock level will be optimal. The profit maximization problem of a representative housing service supplier is:

$$\max \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \left[p_{t,j} I_{t,j}^h - w_{t,j} L_{t,j} - I_{t,j}^c - \frac{g}{2} \frac{(I_{t,j}^c)^2}{K_{t,j}} \right], \quad (2.1.4)$$

$$\text{subject to } I_{t,j}^c = K_{t+1,j} - K_{t,j} \equiv \Delta K_{t+1,j},$$

where r is the real interest rate and $\left(\frac{1}{1+r}\right)$ is the inter-temporal discount factor, and $p_{t,j}$ is the *relative* house price, in terms of the non-housing good. The price of the non-tradable housing rental service is determined in each province, while the price of the non-housing good is determined in the national market. Hence, the relative house price captures interactions between the national market and provincial markets, which is of interest in this paper.² $w_{t,j} L_{t,j}$ is the total wage paid to the labour input in residential investment. Capital is owned by the housing service sector. So, the construction investing spending in residential investment, $I_{t,j}^c$, has to be subtracted

¹The equilibrium in the non-housing sector is not solved explicitly in this thesis, so there is no separate notation for the labour input in the non-housing sector. However, it is important to distinguish between different labour inputs. The labour market clearing condition for each province is “Total labour input = Labour input in the residential investment + Labour input in the non-housing sector.”

²Typically, the new housing is only a fraction of the existing housing stocks, so it will behave as a price-taker.

from the total revenue. $\frac{g}{2} \frac{(I_{t,j}^c)^2}{K_{t,j}}$ captures the cost of adjustment in changing the capital stock, where g is a strictly positive coefficient. Both the construction investing spending and the cost of adjustment altogether can be viewed as the capital expenditure part. Lastly, there is no depreciation in the capital accumulation in construction activities of the housing service sector.

Similarly, the non-housing sector also confronts a profit maximization problem. As the situation in the non-housing sector is not of interest in the research, however, the optimization will not be solved explicitly. The non-housing sector will automatically achieve its optimization in every period. The output of the non-housing sector will be distributed to households in each period, and its price equals to 1.

The demand side of this model is comprised of representative households in each province with preferences over the current and future consumption of the housing rental service and the output from the non-housing sector. Specifically, I consider a constant elasticity of substitution (CES) instantaneous utility function:

$$C_{t,j} \equiv C_{t,j}(C_{n,t,j}, C_{h,t,j}) = [\gamma^{1/\theta} C_{n,t,j}^{(\theta-1)/\theta} + (1-\gamma)^{1/\theta} C_{h,t,j}^{(\theta-1)/\theta}]^{\theta/(\theta-1)}, \quad (2.1.5)$$

$$\gamma \in (0, 1), \theta \in (0, \infty),$$

where $C_{n,t,j}$ and $C_{h,t,j}$ are the consumption of the non-housing good and the housing rental service at time t in province j , respectively. γ is the household preference parameter and it weighs the non-housing consumption and the housing service consumption. θ is the elasticity of substitution in consumption between the non-housing

good and the housing rental service. The lifetime utility function is additively separable over time:

$$U_0 = \sum_{t=0}^{\infty} \rho^t \frac{C_{t,j}^{1-\frac{1}{\sigma}} - 1}{1 - \frac{1}{\sigma}}, \quad \rho \in (0,1), \sigma \in (0, \infty), \quad (2.1.6)$$

where ρ is the discount factor, and σ is the elasticity of inter-temporal substitution.

There is a constant interest rate, r . Consequently, the inter-temporal budget constraint is:

$$W_{t+1,j} = (1+r)W_{t,j} + w_{t,j}^T L_{t,j}^T - P_{t,j} C_{t,j}, \quad (2.1.7)$$

where W is the net wealth of the household, r is the constant interest rate, and $w_{t,j}^T L_{t,j}^T$ is the total labour income in province j at time t .³ $P_{t,j} C_{t,j} = C_{n,t,j} + p_{t,j} C_{h,t,j}$ is the total consumption expenditure in province j at time t . $P_{t,j}$ is a consumption based price index, and $C_{t,j}$ is a composite consumption good consisting of the non-housing good and the housing rental service. In each period, the representative household maximizes its utility function by allocating the consumption of the non-housing good and the housing rental service.

2.2 Solving the Model

The model has two optimization problems: one from the housing service sector (supply side), the other from the household (demand side). Accordingly, the model delivers two regression equations, one for residential investment and the other for relative

³Total wage rate, $w_{t,j}^T$, is an comprehensive wage rate in time t in province j , taking both sectors into consideration. $L_{t,j}^T$ is the total labour supply in province j at time t , which is exogenous in this paper.

house prices.

2.2.1 Residential Investment

I start with the profit maximization problem of the housing service sector. The corresponding *Lagrangian* function is

$$\mathcal{L}_{t,j} = \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \left\{ \left[p_{t,j} I_{t,j}^h - w_{t,j} L_{t,j} - I_{t,j}^c - \frac{g}{2} \frac{(I_{t,j}^c)^2}{K_{t,j}} \right] + \lambda_{t,j} [I_{t,j}^c - \Delta K_{t+1,j}] \right\}, \quad (2.2.1)$$

where $\lambda_{t,j}$ is the shadow price in time t in province j , and the constraint, $I_{t,j}^c - \Delta K_{t+1,j}$, comes from the capital accumulation in residential investment.

The *first-order conditions* with respect to $I_{t,j}^c$ and $K_{t+1,j}$, respectively, are

$$\frac{\partial \mathcal{L}_{t,j}}{\partial I_{t,j}^c} = \left(\frac{1}{1+r} \right)^t \left[(-1) + \lambda_{t,j} - g \left(\frac{I_{t,j}^c}{K_{t,j}} \right) \right] = 0, \quad (2.2.2)$$

and

$$\begin{aligned} \frac{\partial \mathcal{L}_{t,j}}{\partial K_{t+1,j}} &= \left(\frac{1}{1+r} \right)^t (-\lambda_{t,j}) \\ &+ \left(\frac{1}{1+r} \right)^{t+1} \left[\alpha p_{t+1,j} A_{t+1,j} K_{t+1,j}^{\alpha-1} L_{t+1,j}^{1-\alpha} + \frac{g}{2} \left(\frac{I_{t+1,j}^c}{K_{t+1,j}} \right)^2 + \lambda_{t+1,j} \right] = 0, \end{aligned} \quad (2.2.3)$$

where $I_{t+1,j}^h = A_{t+1,j} K_{t+1,j}^{\alpha} L_{t+1,j}^{1-\alpha}$.

Simplifying the equations above, we have

$$I_{t,j}^c = \frac{\lambda_{t,j} - 1}{g} K_{t,j}, \quad (2.2.4)$$

and

$$\lambda_{t+1,j} - \lambda_{t,j} = r\lambda_{t,j} - \alpha p_{t+1,j} A_{t+1,j} K_{t+1,j}^{\alpha-1} L_{t+1,j}^{1-\alpha} - \frac{g}{2} \left(\frac{I_{t+1,j}^c}{K_{t+1,j}} \right)^2. \quad (2.2.5)$$

By differencing equation (2.2.4) and substituting $K_{t-1,j} = K_{t,j} - I_{t-1,j}^c$, we have

$$\Delta I_{t,j}^c = \frac{1}{g} [(\lambda_{t,j} - \lambda_{t-1,j})K_{t,j} + (\lambda_{t-1,j} - 1)I_{t-1,j}^c]. \quad (2.2.6)$$

Using equation (2.2.5), the shadow price of capital can be written as

$$\lambda_{s,j} = \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} \left[\alpha p_{s+1,j} A_{s+1,j} K_{s+1,j}^{\alpha-1} L_{s+1,j}^{1-\alpha} + \frac{g}{2} \left(\frac{I_{s+1,j}^c}{K_{s+1,j}} \right)^2 \right]. \quad (2.2.7)$$

Assuming the cost of adjustment terms are fairly small, the first term in the right-hand-side of equation (2.2.6) can be approximated as

$$(\lambda_{t,j} - \lambda_{t-1,j})K_{t,j} \approx \phi_A \Delta A_{t,j} + \phi_p \Delta p_{t,j}, \quad (2.2.8)$$

where ϕ_A and ϕ_p are positive coefficients that depend on structural parameters. The intuition of equation (2.2.8) is as follows: given fixed level of capital input, if the TFP or the relative house price increases, the “price” that a representative supplier will have to pay for postponing investment will increase as well. Substituting equation (2.2.8) into equation (2.2.6) gives

$$\Delta I_{t,j}^c = \phi_A \Delta A_{t,j} + \phi_p \Delta p_{t,j} + \frac{1}{g} (\lambda_{t-1,j} - 1) I_{t-1,j}^c. \quad (2.2.9)$$

Let $\lambda_{t,j}$ be a process deviating from the steady-state value of λ , $\bar{\lambda}$, with a random term $\xi_{t,j}$, which is proportional to the level of past investment, namely $\lambda_{t-1,j} - 1 = \bar{\lambda} + \xi_{t,j}/I_{t-1,j}^c$, equation (2.2.9) can be simplified as:

$$\Delta I_{t,j}^c = \phi_A \Delta A_{t,j} + \phi_p \Delta p_{t,j} + \phi_g I_{t-1,j}^c + \frac{1}{g} \xi_{t,j}, \quad (2.2.10)$$

where $\phi_g = \frac{\bar{\lambda}}{g}$.⁴

As fluctuations in residential investment (i.e. changes in the new housing starts, $\Delta I_{t,j}^h$) is economically more interesting than that in the capital input in construction activities ($\Delta I_{t,j}^c$), further simplifications can be made to substitute $\Delta I_{t,j}^h$ for $\Delta I_{t,j}^c$ in the equation (2.2.10) above.

First, rewrite equation (2.2.10) in its growth rate form

$$\Delta \ln I_{t,j}^c = \phi_A \Delta \ln A_{t,j} + \phi_p \Delta \ln p_{t,j} + \phi_g \ln I_{t-1,j}^c + \frac{1}{g} \ln \xi_{t,j}. \quad (2.2.11)$$

Second, take the log transformation on both sides of the residential investment function (2.1.3),

$$\ln I_{t,j}^h = \ln A_{t,j} + \alpha \ln K_{t,j} + (1 - \alpha) \ln L_{t,j}, \quad (2.2.12)$$

and then take first difference transformation,

$$\Delta \ln I_{t,j}^h = \Delta \ln A_{t,j} + \alpha \Delta \ln K_{t,j} + (1 - \alpha) \Delta \ln L_{t,j}. \quad (2.2.13)$$

Approximate the constraint condition in equation (2.1.4), $\Delta K_{t,j} = I_{t-1,j}^c$, in its growth rate form,

$$\Delta \ln K_{t,j} = \ln I_{t-1,j}^c. \quad (2.2.14)$$

Then, by substituting equation (2.2.13) into equation (2.2.11),

⁴Although g is a strictly positive coefficient, the sign of $\bar{\lambda}$ cannot be determined, therefore, the sign of ϕ_g cannot be determined.

$$\begin{aligned} \Delta \ln I_{t,j}^c &= \phi_A \Delta \ln A_{t,j} + \phi_p \Delta \ln p_{t,j} \\ &+ \phi_g \left[\frac{\Delta \ln I_{t,j}^h - \Delta \ln A_{t,j} - (1 - \alpha) \Delta \ln L_{t,j}}{\alpha} \right] + \frac{1}{g} \ln \xi_{t,j}. \end{aligned} \quad (2.2.15)$$

As $\Delta \ln I_{t,j}^c$ equals to $\Delta^2 K_{t+1,j}$, which is very small, I assume it equals to 0 for simplicity. This gives the regression equation of residential investment for province j at time t ,

$$\Delta \ln I_{t,j}^h = \beta_0 + \beta_1 \Delta \ln A_{t,j} + \beta_2 \Delta \ln p_{t,j} + \beta_3 \Delta \ln L_{t,j} + \epsilon_{t,j}^I, \quad (2.2.16)$$

where β_0 is the intercept term, $\beta_1 = 1 - \frac{\alpha \phi_A}{\phi_g}$, $\beta_2 = -\frac{\alpha \phi_p}{\phi_g}$, $\beta_3 = 1 - \alpha$, and $\epsilon_{t,j}^I = -\frac{\alpha}{g \phi_g} \ln \xi_{t,j}$. β_0 , β_1 , and β_2 can be either positive or negative, and β_3 should be positive.

2.2.2 Relative House Prices

Now turn to the demand side of this model. A representative household faces the following utility optimization problem:

$$\max \sum_{t=0}^{\infty} \rho^t \frac{C_{t,j}^{1-\frac{1}{\sigma}} - 1}{1 - \frac{1}{\sigma}}, \quad (2.2.17)$$

$$\text{subject to } W_{t+1,j} = (1 + r)W_{t,j} + w_{t,j}^T L_{t,j}^T - P_{t,j} C_{t,j}.$$

This is a two-stage utility maximization problem. In the first stage, the household determines its optimal level of consumption in each period. The interest rate is constant, and the level of wealth at the beginning of each period is fixed. In the

second stage, the household decides how to allocate the consumption expenditure within each period between the non-housing good and the housing rental service, based on the instantaneous utility function (2.1.5) and relative housing prices.

To solve the first stage problem, rewrite the inter-temporal budget constraint as

$$C_{t,j} = \frac{(1+r)W_{t,j} - W_{t+1,j} + w_{t,j}^T L_{t,j}^T}{P_{t,j}}, \quad (2.2.18)$$

then substitute this new budget constraint into the inter-temporal utility function and obtain

$$U_0 = \sum_{t=0}^{\infty} \rho^t \frac{\left[\frac{(1+r)W_{t,j} - W_{t+1,j} + w_{t,j}^T L_{t,j}^T}{P_{t,j}} \right]^{1-\frac{1}{\sigma}} - 1}{1 - \frac{1}{\sigma}}. \quad (2.2.19)$$

Taking derivative with respect to $W_{t+1,j}$, the inter-temporal Euler equation on total consumption expenditures is

$$C_{t+1,j} = \left(\frac{P_{t,j}}{P_{t+1,j}} \right)^{\sigma} (1+r)^{\sigma} \rho^{\sigma} C_{t,j}. \quad (2.2.20)$$

In the second stage, the household allocates the consumption expenditure within time t between the non-housing good and the housing rental services.⁵ Specifically,⁶

$$\begin{aligned} \max C_j &= [\gamma^{1/\theta} C_{n,j}^{(\theta-1)/\theta} + (1-\gamma)^{1/\theta} C_{h,j}^{(\theta-1)/\theta}]^{\theta/(\theta-1)}, \\ \text{subject to } Z_j &= C_{n,j} + p_j C_{h,j}, \end{aligned} \quad (2.2.21)$$

where Z_j is the total consumption expenditures within a period. Applying the Lagrangian function, we can obtain the optimal relationship between the housing rental

⁵The derivations here are standard and I follow Obstfeld and Rogoff (1996) closely.

⁶I drop the time subscript here for notational convenience as there is only one time period involved in this part.

service consumption and the non-housing consumption:

$$\frac{\gamma C_{h,j}}{(1-\gamma)C_{n,j}} = p_j^{-\theta}. \quad (2.2.22)$$

Together with the budget constraint above, the consumption of the non-housing good and the housing rental service can be rewritten in terms of the total consumption expenditure Z , respectively, as

$$C_{h,j} = \frac{p_j^{-\theta}(1-\gamma)Z_j}{\gamma + (1-\gamma)p_j^{1-\theta}}, \quad (2.2.23)$$

and

$$C_{n,j} = \frac{\gamma Z_j}{\gamma + (1-\gamma)p_j^{1-\theta}}. \quad (2.2.24)$$

Substituting equation (2.2.23) and (2.2.24) into the CES utility function, we have

$$\left\{ \gamma^{1/\theta} \left[\frac{\gamma Z_j}{\gamma + (1-\gamma)p_j^{1-\theta}} \right]^{\frac{\theta-1}{\theta}} + (1-\gamma)^{1/\theta} \left[\frac{p_j^{-\theta}(1-\gamma)Z_j}{\gamma + (1-\gamma)p_j^{1-\theta}} \right]^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}}. \quad (2.2.25)$$

Define a consumption based price index P_j as the minimum expenditure $Z_j = C_{n,j} + p_j C_{h,j}$ such that the total consumption equals to 1, given p_j , we have

$$\left\{ \gamma^{1/\theta} \left[\frac{\gamma P_j}{\gamma + (1-\gamma)p_j^{1-\theta}} \right]^{\frac{\theta-1}{\theta}} + (1-\gamma)^{1/\theta} \left[\frac{p_j^{-\theta}(1-\gamma)P_j}{\gamma + (1-\gamma)p_j^{1-\theta}} \right]^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}} = 1. \quad (2.2.26)$$

And the solution is

$$P_j = [\gamma + (1-\gamma)p_j^{1-\theta}]^{\frac{1}{1-\theta}}. \quad (2.2.27)$$

$\frac{Z_j}{P_j}$ is the ratio of a household's total expenditure in terms of the non-housing traded good, to the minimum price level of a single unit of the consumption index, which is also measured in the non-housing traded good. Therefore, $\frac{Z_j}{P_j}$ equals to the consumption level, C_j , which an optimizing household will have

$$C_j = \frac{Z_j}{P_j}. \quad (2.2.28)$$

Then, by substituting the above relationship (2.2.28) into equation (2.2.23) and (2.2.24), and simplifying them with equation (2.2.27), we have

$$C_{h,j} = (1 - \gamma) \left(\frac{p_j}{P_j} \right)^{-\theta} C_j, \quad (2.2.29)$$

and

$$C_{n,j} = \gamma \left(\frac{1}{P_j} \right)^{-\theta} C_j. \quad (2.2.30)$$

Consequently, by applying the Euler equation (2.2.20), the inter-temporal consumption behavior for the composite traded good and the housing rental service, respectively, are (with time subscripts)

$$C_{h,t+1,j} = \left(\frac{P_{t,j}}{P_{t+1,j}} \right)^{\sigma-\theta} \left(\frac{p_{t+1,j}}{p_{t,j}} \right)^{-\theta} (1+r)^\sigma \rho^\sigma C_{h,t,j}, \quad (2.2.31)$$

and

$$C_{n,t+1,j} = \left(\frac{P_{t,j}}{P_{t+1,j}} \right)^{\sigma-\theta} (1+r)^\sigma \rho^\sigma C_{n,t,j}. \quad (2.2.32)$$

To keep the demand side as simple as possible, let $(1+r)\rho = 1$ and $\sigma = \theta$. Therefore, for the non-housing sector,

$$C_{n,t+1,j} - C_{n,t,j} \equiv \Delta C_{n,t,j} = 0, \forall t \geq 0. \quad (2.2.33)$$

For the housing sector, however, in general $\Delta C_{h,t,j} \neq 0$.

As fluctuations of relative house prices, $p_{t,j}$, is another variable of interest in this research, I apply the accounting identity of the provincial economic accounts to derive the regression equation regarding the relative house prices. The provincial accounting identity is

$$Y_{t,j} = C_{n,t,j} + p_{t,j}C_{h,t,j} + I_{t,j}^h + NX_{t,j}, \quad (2.2.34)$$

where $Y_{t,j}$ is the provincial GDP in time t in province j . $C_{n,t,j}$ and $C_{h,t,j}$ are the consumption level in the non-housing sector (n) and in the housing service sector (h), respectively. $I_{t,j}^h$ is residential investment. And finally, $NX_{t,j}$ is the net trade balance in time t in province j .

Approximate equation (2.2.34) in its log form and then apply the first difference operator Δ :

$$\Delta \ln Y_{t,j} = \Delta \ln p_{t,j} + \Delta \ln C_{h,t,j} + \Delta \ln I_{t,j}^h + \Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right).^7 \quad (2.2.35)$$

As the available data for $C_{h,t,j}$ is very short, I drop this variable in the final regressions. By substituting equation (2.2.16) in the above equation and simplifying for $\Delta \ln p_{t,j}$, it is possible to obtain another regression equation, relating the growth of prices to the shock term ($\Delta \ln A_{t,j}$), the labour input ($\Delta \ln L_{t,j}$), the provincial GDP ($\Delta \ln Y_{t,j}$), and the net trade balance ($\Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right)$):

⁷We cannot take the logarithm of $NX_{t,j}$, since its value might be negative in some periods. So I use $\left(\frac{NX_{t,j}}{Y_{t,j}} \right)$ to measure the “growth rate” of the net export.

$$\Delta \ln p_{t,j} = \gamma_0 + \gamma_1 \Delta \ln A_{t,j} + \gamma_2 \Delta \ln L_{t,j} + \gamma_3 \Delta \ln Y_{t,j} + \gamma_4 \Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right) + \epsilon_{t,j}^p, \quad (2.2.36)$$

where $\gamma_0 = -\frac{\beta_0}{1+\beta_2}$, $\gamma_1 = -\frac{\beta_1}{1+\beta_2}$, $\gamma_2 = -\frac{\beta_3}{1+\beta_2}$, $\gamma_3 = \frac{1}{1+\beta_2}$, $\gamma_4 = -\frac{1}{1+\beta_2}$, and $\epsilon_{t,j}^p = -\frac{1}{1+\beta_2} \epsilon_{t,j}^I$. There is no theoretical restriction on the direction of these coefficients, all of them can be either positive or negative.

To address the main objective of this thesis, namely, to compare and contrast the contributions of region-specific shocks and aggregate shocks to residential investment and relative house prices, the general shock terms $\Delta \ln A_{t,j}$ will be disentangled into a region-specific component ($\Delta \ln A_{t,j}^P$) and an aggregate component ($\Delta \ln A_{t,j}^F$), according to the following steps.

First, calculate the total-factor productivity, $\Delta \ln A_{t,j}$, for each province. Applying the growth decomposition formula,

$$\Delta \ln A_{t,j} = \Delta \ln I_{t,j}^h - \alpha \Delta \ln K_{t,j} - (1 - \alpha) \Delta \ln L_{t,j}, \quad (2.2.37)$$

where $I_{t,j}^h$ is the residential investment in province j at time t , $K_{t,j}$ is the capital input, and $L_{t,j}$ is the labour input in residential investment, respectively.⁸

Once we obtain the growth rate of total-factor productivity, we can start to disentangle region-specific shocks, $\Delta \ln A_{t,j}^P$, and aggregate shocks, $\Delta \ln A_{t,j}^F$, following the method proposed by Glick and Rogoff (1995).

Glick and Rogoff (1995) suggest two different methods. The first one is to take the GDP-weighted average TFP growth rate as national aggregate shocks, and subtract

⁸In preliminary analysis, I have used three different values of α (0.3, 0.4 and 0.5) but there had no significant impact on the final regression results. Therefore, this thesis reports the results only for $\alpha = 0.3$.

it from the provincial TFP to get region-specific shocks:

$$\Delta \ln A_{t,j}^P = \Delta \ln A_{t,j} - \Delta \ln A_{t,j}^F. \quad (2.2.38)$$

Region-specific shocks captured here are the deviations from national average shock level. Also, region-specific shocks and aggregate shocks in this thesis are essentially “region and industry (construction) specific shocks” and “aggregate and industry (construction) specific shocks.”

The second method has the same starting point and takes the GDP-weighted TFP as aggregate shocks. But the second method uses the GDP-weighted average TFP of other nine provinces to regress the provincial TFP of interest and treats the the residual as regional-specific shocks. The final regression results based on the two methods are not significantly different from each other. Therefore, this thesis reports results based on the first method.

After substituting region-specific shocks and aggregate shocks into equation (2.2.16) and (2.2.36), respectively,

$$\Delta \ln I_{t,j}^h = \beta_0 + \beta_4 \Delta \ln A_{t,j}^F + \beta_5 \Delta \ln A_{t,j}^P + \beta_2 \Delta \ln p_{t,j} + \beta_3 \Delta \ln L_{t,j} + \epsilon_{t,j}^I, \quad (2.2.39)$$

$$\begin{aligned} \Delta \ln p_{t,j} = & \gamma_0 + \gamma_5 \Delta \ln A_{t,j}^F + \gamma_6 \Delta \ln A_{t,j}^P + \gamma_2 \Delta \ln L_{t,j} + \gamma_3 \Delta \ln Y_{t,j} \\ & + \gamma_4 \Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right) + \epsilon_{t,j}^p. \end{aligned} \quad (2.2.40)$$

The discussion of β_4 , β_5 , γ_5 , and γ_6 will be an important part of the regression analysis, as their directions and significance reflect contributions of region-specific shocks and aggregate shocks to residential investment and relative house prices, respectively.

Moreover, there are also economic expectations on other coefficients in the regression model above. First, β_2 should be positive. Intuitively, as the relative house price increases, residential investment should increase as well. Second, β_3 should also be positive, which means the amount of labour input should be positively related to residential investment. The same argument also applies to γ_2 , as the higher the house price, the more housing investment, there will be more demand on the construction labour input.

Chapter 3

Empirical Analysis

3.1 Data Retrieval and Preparation

In the empirical part of this thesis, I consider ten provinces in Canada. They are Nova Scotia (NS), New Brunswick (NB), Prince Edward Island (PEI), Newfoundland and Labrador (NL), Quebec (QC), Ontario (ON), Manitoba (MB), Saskatchewan (SK), Alberta (AB), and British Columbia (BC).

The conceptual framework in Chapter 2 delivers two regression equations for each province. I stack these equations and construct a twenty-equation regression model:

$$\begin{aligned} \Delta \ln I_{t,j}^h = & \beta_0 + \beta_4 \Delta \ln A_{t,j}^F + \beta_5 \Delta \ln A_{t,j}^P + \beta_2 \Delta \ln p_{t,j} + \beta_3 \Delta \ln L_{t,j} \\ & + \beta_6 \Delta \ln Y_{t,j} + \beta_7 \Delta \ln Y_{t,j}^{ROC} + \epsilon_{t,j}^I, \end{aligned} \quad (3.1.1)$$

$$\begin{aligned} \Delta \ln p_{t,j} = & \gamma_0 + \gamma_5 \Delta \ln A_{t,j}^F + \gamma_6 \Delta \ln A_{t,j}^P + \gamma_2 \Delta \ln L_{t,j} + \gamma_3 \Delta \ln Y_{t,j} \\ & + \gamma_4 \Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right) + \gamma_7 \Delta \ln Y_{t,j}^{ROC} + \epsilon_{t,j}^p, \end{aligned} \quad (3.1.2)$$

where the subscript j serves as the province indicator, and $Y_{t,j}^{ROC}$ is the sum of provincial GDP of all provinces excluding province j , at time t . I include $\Delta \ln Y_{t,j}$ and

$\Delta \ln Y_{t,j}^{ROC}$ in both equations to capture the income effects, which are not otherwise included in the conceptual framework. Consequently, β_6 , β_7 , and γ_7 are flexible coefficients.

The data collected for the regression model is as follows: residential investment ($\Delta \ln I_{t,j}^h$) is measured by the “Residential Construction Investment” from Canadian Mortgage and Housing Corporation (CMHC). According to the definition, the residential construction investment includes three components: new housing construction, renovations given improvements, alterations and modifications to existing dwellings, and the acquisition of new dwellings. The data collected covers all the investment for residential buildings as well as all renovations made on existing residential buildings in the Canadian economy.

The capital input in residential investment ($\Delta \ln K_{t,j}$) is measured by capital expenditures on “housing”. “Housing” here is not a NAICS industry, but represents an allocation made for residential housing construction in order to display the total investment (i.e. residential and non-residential). It is based upon estimates from CMHC.

The labour input in residential investment ($\Delta \ln L_{t,j}$) is measured by the “Employment in the construction (seasonally adjusted)” from the labour force survey (LFS).¹

The relative house price ($\Delta \ln p_{t,j}$) is measured by the ratio of the “CPI: Shelter” to the “CPI: All-items excluding shelter”. “CPI: Shelter” incorporates three components, the first component is the rented accommodation, including rent, tenants’

¹The breakdown for residential housing construction is not available. So I take this employment in the whole construction sector, as an approximation.

insurance premiums, and tenants' maintenance, repairs and other expenses. The second component is the owned accommodation, including mortgage interest cost, replacement cost, property taxes (including special charges), homeowners' home and mortgage insurance, homeowners' maintenance and repairs, and other owned accommodation expenses. The third component includes the expenses of electricity, water, natural gas, fuel oil and other fuels.

The provincial GDP ($\Delta \ln Y_{t,j}$) comes from the provincial economic accounts.

The inter-provincial net trade balance of each province ($NX_{t,j}$) comes from the "Input-Output Structure of the Canadian Economy in Current Prices".

Data are annual and from 1986 to 2007. Appendix A provides further details about the data sources.

3.2 Estimation Method

This thesis uses the seemingly unrelated regression estimation (SURE) method. This method is suitable for several individual relationships that are linked by correlated disturbances, as it is the case here. In particular, the partial segmentation of different local housing markets in Canada provide a natural application of the SURE method, as different local housing markets are likely to be linked by spillovers from omitted aggregate shocks.

3.3 Descriptive Analysis

Before analyzing the regression results, this section provides a descriptive analysis and historical perspective.

Based on the geographic adjacency, four Atlantic Provinces and three Prairie Provinces are grouped together.

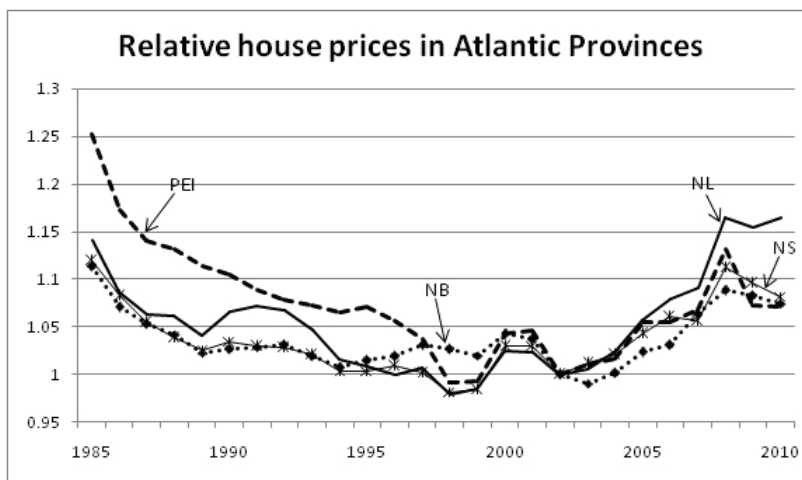


Figure 3.1: Relative house prices in Atlantic Provinces, 1985-2009

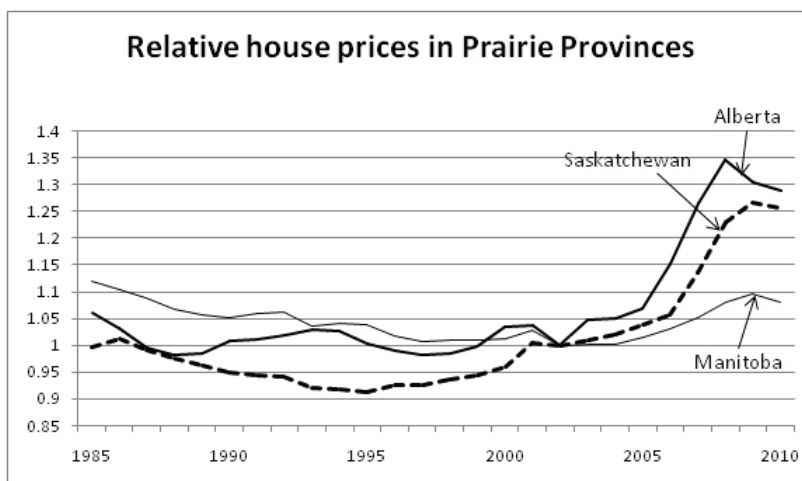


Figure 3.2: Relative house prices in Prairie Provinces, 1985-2009

Figure 3.1 demonstrates relative house prices in the four Atlantic Canada Provinces. For most of the period after 1985, relative house prices in Atlantic Provinces exhibit significant resemblance to each other. Figure 3.2 shows similar trends about relative house prices in Prairie Provinces. This evidence suggests that connections between local housing markets within the same group are stronger than otherwise. In other words, local housing markets within the same group are likely to share similar aggregate shocks.

The fluctuations of residential investment is another variable of interest in this thesis. Figures 3.3 and 3.4 present residential investment to the provincial GDP in Atlantic Provinces and Prairie Provinces. Provinces within each group still exhibit similarity, which reinforces the notion that local housing markets within the same group expose to similar aggregate shock.

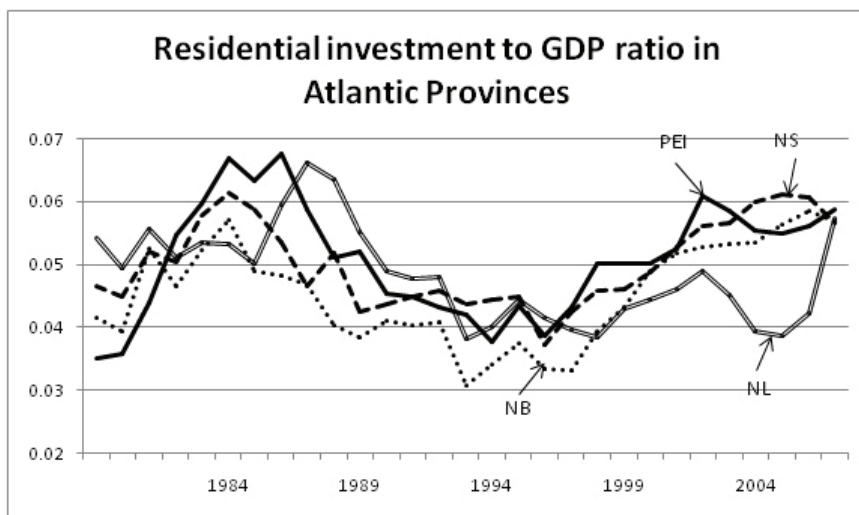


Figure 3.3: Residential investment to GDP ratio in Atlantic Provinces, 1981-2009

After grouping four Atlantic Provinces and three Prairie Provinces together, the situations in Canada can be presented by five major regions: BC, Prairie Provinces,

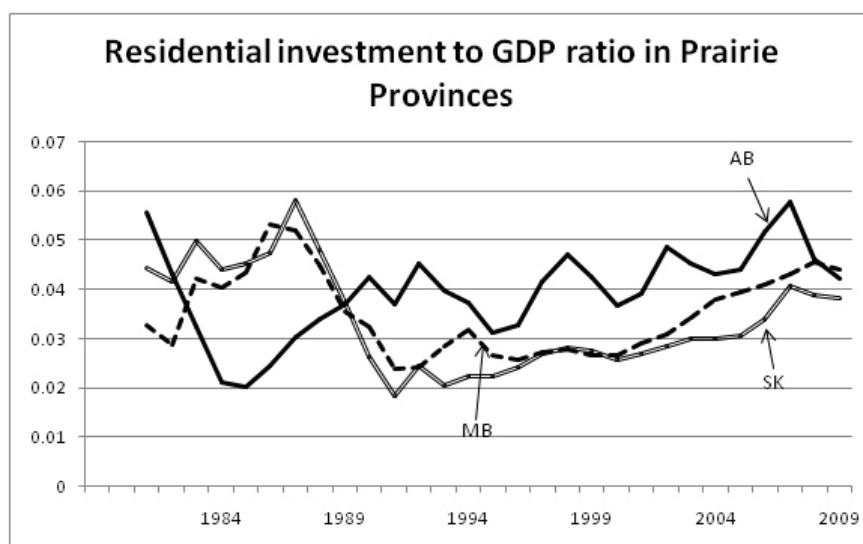


Figure 3.4: Residential investment to GDP ratio in Prairie Provinces, 1981-2009

Ontario, Quebec, and Atlantic Provinces. Figures 3.5 and 3.6 display the relative house prices and the residential investment to GDP ratios, respectively. In the figures, the Prairie Provinces stand out as the relative house price rises rapidly after 2005 and reaches its peak in 2007. Although it declines slightly after 2007, the relative house price in Prairie Provinces remains significantly higher than that in the rest of Canada. By contrast, the ratio of residential investment to GDP in Prairie Provinces is the lowest among five regions after 2000, suggesting that high housing price is not necessarily leading to high residential investment.

British Columbia is equally interesting. The relative house price began to fall gradually from 1985 to 2009, which was probably due to the recovery from the serious housing market bubbles in the early 1980s. Conversely, residential investment to GDP ratio in BC has been the highest from year 2005, which suggests that low housing price is not necessarily leading to low residential investment. Together with the above observation in Prairie Regions, the local housing price seems do not closely correlated

with local residential investment in Canada during the period from 1986 to 2007.

Other three areas do not show dramatic movements as previous two regions, maintaining a relatively stable housing market.

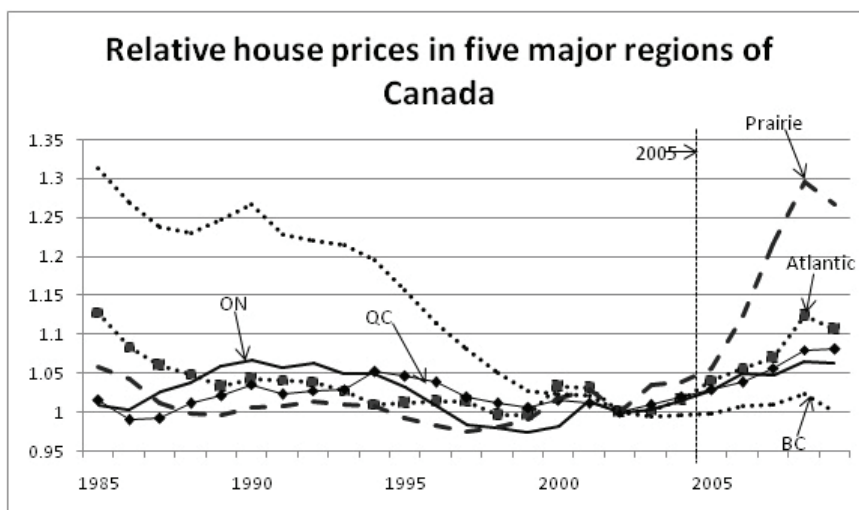


Figure 3.5: Relative house prices in five major regions of Canada, 1985-2009

3.4 Regression Analysis

According to the estimation results, the conceptual framework explains residential investment better than it explains relative house prices. Variables of interest are those that control for region-specific shocks, $\Delta \ln A_{t,j}^P$, and aggregate shocks, $\Delta \ln A_{t,j}^F$. In residential investment regressions, coefficients on these two variables are positive in all the provinces and are statistically significant, only except for region-specific shocks in Ontario. Based on the relationship between region-specific shocks and aggregate shocks, these ten provinces can be divided into three groups. In New Brunswick, Ontario, and British Columbia, aggregate shocks dominate region-specific shocks. In other Atlantic Provinces: Nova Scotia, Newfoundland, and PEI, impacts of both

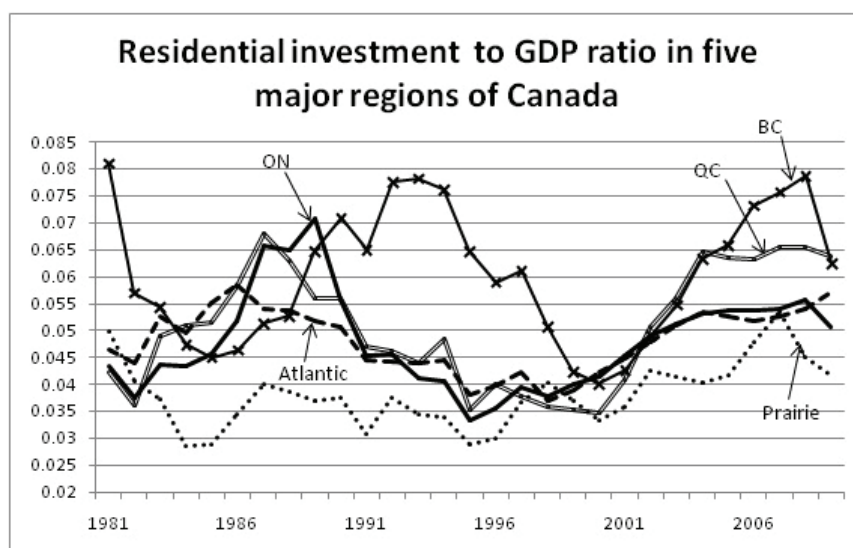


Figure 3.6: Residential investment to GDP ratio in five major regions of Canada, 1981-2009

kinds of shocks are comparable to each other, although the coefficients on aggregate shocks are slightly greater than that of region-specific shocks. In Quebec and Prairie Provinces, however, the impacts of region-specific shocks outweigh that of aggregate shocks.

Overall, investment in housing in Atlantic Provinces, Ontario, and BC, responds by more to aggregate shocks. By contrast, in Quebec and Prairie Provinces, investment in housing responds by more to region-specific shocks.

The results of relative house prices are not as clear cut as that of residential investment. In terms of directions and relationships of responses to region-specific shocks and aggregate shocks, the estimated responses of region-specific shocks are higher than that of aggregate shocks. Apart from that, it is very difficult to categorize different provinces into groups, based on their reaction patterns to different shock terms. The relative house price emerges as a region-specific variable and price linkages

across different provinces are in general weak.

In residential investment functions, the growth rate of the relative house price is another variable of interest. The results are puzzling, however. Intuitively, the growth rate of the relative house price should be positively related to the growth rate of residential investment. However, four provinces (NL, QC, MB, and SK) exhibit negative coefficients on housing prices.

Estimation results of the growth rate of the employment in the construction sector are uniformly positive in both equations of all provinces, which is expected according to the conceptual framework. This variable is also statistically significant except for relative house price functions of PEI and Ontario.

The growth rates of the provincial GDP and the GDP of the rest of Canada (i.e. the other nine provinces) in residential investment regressions are used to capture the possibly omitted income effect. Neither of the coefficients associated with these two variables are significant in most of the regression results, which means the income effect is less relevant to fluctuations of residential investment in Canada during the period from 1986 to 2007.

On the contrary, in relative house price regressions, based on the estimation results of the provincial GDP and the GDP of the rest of Canada, these ten provinces can be divide into two groups. The first group includes three Atlantic Provinces (Nova Scotia, New Brunswick, and PEI), Ontario and Quebec, in which the growth rate of the relative house price is negatively related to its own GDP but positively related to the GDP of the rest of Canada. The second group is comprised of Newfoundland, and three Prairie Provinces, in which the growth rate of relative housing price is

positively related to its own GDP but negatively related to the GDP of rest of Canada. The reason why housing prices are positively related to provincial GDP in Prairie Provinces and Newfoundland might be the dominating position of the oil industry in these four provinces during 1986-2007. As the booming oil industry pushed up the provincial GDP, it also brought a large number of workers and their families and the demand of housing services increased. For that reason, the provincial GDP could be positively related to the relative housing price above and beyond the variables considered in the conceptual framework.

Table 3.1: Regression results: ten provinces in Canada, 1986-2007

	$\Delta \ln A_{t,j}^F$	$\Delta \ln A_{t,j}^P$	$\Delta \ln p_{t,j}$	$\Delta \ln L_{t,j}$	$\Delta \ln Y_{t,j}$	$\Delta \ln Y_{t,j}^{ROC}$	$\Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right)$	Const	R^2
NS	$\Delta \ln I_{t,j}^h$ 1.285 (0.039)	1.247 (0.010)	0.170 (0.052)	0.896 (0.019)	-0.058 (0.044)	0.049 (0.119)		0.002 (0.003)	0.980
	$\Delta \ln p_{t,j}$ 0.055 (0.052)	0.079 (0.012)		0.108 (0.030)	-0.264 (0.074)	0.145 (0.164)	0.228 (0.053)	-0.001 (0.004)	0.300
NB	$\Delta \ln I_{t,j}^h$ 1.370 (0.057)	1.048 (0.025)	0.158 (0.117)	0.646 (0.045)	-0.343 (0.097)	0.720 (0.184)		-0.007 (0.004)	0.970
	$\Delta \ln p_{t,j}$ -0.075 (0.047)	-0.032 (0.012)		0.051 (0.026)	-0.445 (0.048)	0.314 (0.145)	0.058 (0.024)	0.002 (0.003)	0.270
NL	$\Delta \ln I_{t,j}^h$ 1.382 (0.057)	1.358 (0.015)	-0.204 (0.055)	0.937 (0.015)	0.099 (0.016)	-0.101 (0.172)		-0.000 (0.004)	0.970
	$\Delta \ln p_{t,j}$ -0.076 (0.066)	0.070 (0.032)		0.047 (0.030)	0.045 (0.044)	-0.015 (0.198)	0.095 (0.031)	-0.003 (0.005)	0.180
PEI	$\Delta \ln I_{t,j}^h$ 1.484 (0.040)	1.467 (0.009)	0.005 (0.041)	1.021 (0.008)	0.161 (0.025)	-0.234 (0.119)		0.001 (0.003)	0.990
	$\Delta \ln p_{t,j}$ -0.111 (0.064)	0.022 (0.036)		0.030 (0.030)	-0.642 (0.088)	0.663 (0.187)	0.105 (0.044)	-0.002 (0.004)	0.480

Table 3.1: Regression results: ten provinces in Canada, 1986-2007 (Cont'd)

1986-2007	22 Obs	$\Delta \ln A_{t,j}^F$	$\Delta \ln A_{t,j}^P$	$\Delta \ln p_{t,j}$	$\Delta \ln L_{t,j}$	$\Delta \ln Y_{t,j}$	$\Delta \ln Y_{t,j}^{ROC}$	$\Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right)$	Const	R^2
QC	$\Delta \ln I_{t,j}^h$	0.923 (0.125)	1.223 (0.062)	-0.242 (0.273)	0.763 (0.056)	0.620 (0.261)	0.593 (0.386)		-0.018 (0.010)	0.910
	$\Delta \ln p_{t,j}$	-0.072 (0.029)	0.090 (0.017)		0.050 (0.013)	-0.245 (0.084)	0.474 (0.106)	-0.090 (0.058)	-0.005 (0.002)	0.460
ON	$\Delta \ln I_{t,j}^h$	1.147 (0.130)	0.091 (0.124)	0.030 (0.252)	0.522 (0.122)	1.756 (0.317)	0.058 (0.344)		-0.034 (0.011)	0.920
	$\Delta \ln p_{t,j}$	0.059 (0.046)	-0.068 (0.040)		0.037 (0.041)	-0.015 (0.105)	0.260 (0.109)	0.082 (0.093)	-0.006 (0.004)	0.240
MB	$\Delta \ln I_{t,j}^h$	0.933 (0.192)	1.310 (0.052)	-0.862 (0.306)	0.906 (0.049)	0.205 (0.240)	-0.255 (0.584)		0.010 (0.014)	0.780
	$\Delta \ln p_{t,j}$	-0.051 (0.036)	0.021 (0.014)		0.060 (0.013)	0.145 (0.066)	-0.138 (0.113)	-0.104 (0.028)	-0.000 (0.003)	0.280
SK	$\Delta \ln I_{t,j}^h$	1.030 (0.219)	1.154 (0.027)	-0.416 (0.144)	1.081 (0.033)	0.008 (0.078)	-0.108 (0.651)		0.011 (0.016)	0.830
	$\Delta \ln p_{t,j}$	0.114 (0.055)	0.066 (0.016)		0.054 (0.020)	0.133 (0.039)	-0.270 (0.166)	-0.196 (0.035)	0.006 (0.004)	0.360

Table 3.1: Regression results: ten provinces in Canada, 1986-2007 (Cont'd)

1986-2007	22 Obs		$\Delta \ln A_{t,j}^F$	$\Delta \ln A_{t,j}^P$	$\Delta \ln p_{t,j}$	$\Delta \ln L_{t,j}$	$\Delta \ln Y_{t,j}$	$\Delta \ln Y_{t,j}^{ROC}$	$\Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right)$	Const	R^2
AB	$\Delta \ln I_{t,j}^h$		0.672 (0.243)	1.556 (0.114)	0.482 (0.195)	0.825 (0.147)	-0.107 (0.140)	-0.869 (0.673)		0.035 (0.018)	0.610
	$\Delta \ln p_{t,j}$		0.082 (0.084)	-0.041 (0.051)		0.153 (0.050)	0.204 (0.068)	-0.445 (0.234)	-0.044 (0.058)	0.004 (0.006)	0.350
BC	$\Delta \ln I_{t,j}^h$		1.108 (0.114)	0.541 (0.069)	1.510 (0.281)	0.592 (0.081)	1.973 (0.333)	-1.962 (0.378)		0.013 (0.009)	0.930
	$\Delta \ln p_{t,j}$		0.005 (0.039)	0.047 (0.011)		0.132 (0.015)	-0.012 (0.056)	-0.054 (0.110)	-0.008 (0.046)	-0.006 (0.003)	0.490

Note: Δ is the first difference operator. $\Delta \ln I_{t,j}^h$ is the growth rate of residential investment. $\Delta \ln p_{t,j}$ is the growth rate of relative house prices. $\Delta \ln A_{t,j}^F$ is the growth rate of aggregate shocks in time t in province j , $\Delta \ln A_{t,j}^P$ is the growth rate of region-specific shocks, $\Delta \ln L_{t,j}$ is the growth rate of the labour input in construction activities, $\Delta \ln Y_{t,j}$ is the GDP growth rate, $\Delta \ln Y_{t,j}^{ROC}$ is the GDP growth rate of Canada except province j , $\Delta \left(\frac{NX_{t,j}}{Y_{t,j}} \right)$ is the ratio of the net export to the provincial GDP, Const is the intercept term of the regression. Standard errors are reported in parentheses.

Chapter 4

Conclusion

This thesis provides a dynamic partial equilibrium analysis of local housing markets in Canada during the period of 1986 - 2007. It has two major conclusions. First, while in Quebec and three Prairie Provinces, residential investment is more likely to be affected by region-specific shocks, in four Atlantic Provinces, Ontario, and BC, residential investment is more responsive to aggregate shocks. Second, the relative house price is highly region-specific.

Several limits of this research should also be acknowledged. First, the conceptual framework is a supply-oriented model, as the demand side of the economy is greatly simplified for tractability. Therefore, it may neglect some meaningful aspects of the feedback from the demand side. Second, this thesis assumes a simple constant returns to scale production function, and does not take either increasing returns to scale or decreasing returns to scale into consideration. Third, simultaneous equations estimation method is desirable for the purpose of this research, but there is not enough data available to identify the simultaneous equations regression model, further testing and modification of the model should be implemented when more data become available. Lastly, the data set applied here is relatively aggregated. Ideally, distinguishing the

residential housing of different price tiers is more desirable, as their behaviors may be significantly different from each other.

Appendix A

Table A.1: Data sources

Variable	Description	Source
$I_{t,j}^h$ Residential investment	Residential values, quarterly (Dollars), Total residential investment (Mar-1961 to Dec-2010); Table-260013	CMHC and National Account
$K_{t,j}$ Capital input in residential investment	Capital expenditures on construction and machinery and equipment, by industry, provinces and territories, actual data, annually; Housing; 1956-2011; Table-290005/290034	Statistics Canada and CMHC
$L_{t,j}$ Labour input in residential investment	Labour force survey (LFS) estimates, employment by North American Industry Classification System (NAICS), seasonally adjusted, monthly 1976-2001 (Persons) Construction [23]; TABLE 2820088	Labour force survey (LFS)
$p_{t,j}$ Relative house price	Consumer Price Index (CPI), 2005 basket, annually (2002=100); Shelter (1979 to 2010), Table 3260021; All-items excluding shelter (1985 to 2010); Table 3260021	CPI

Table A.1: Data sources (Cont'd)

Variable	Description	Source
$NX_{t,j}$ Inter-provincial trade balance	Final demand categories, by commodity, S-level aggregation, annually (Dollars); Total, final demand(1997 to 2007); Table-3810012 and “Interprovincial Trade in Canada 1984-1996” Catalogue no. 15-546-XPE	Input-Output Structure of the Canadian Economy in Current Prices and the National Accounts
$Y_{t,j}$ Provincial GDP	Gross domestic product (GDP), expenditure-based, provincial economic accounts, annually (Dollars); Current prices; GDP (1981 to 2009); Table 3840002	The Provincial Economic Accounts program

Appendix B

In order to verify whether the regression results are sensitive to region-specific shocks or aggregate shocks, I also run another set of regressions, with the same structure and method but omit those two shock terms. The result of this sensitivity test, in which the R^2 drops dramatically in all residential investment functions and relative house price functions, demonstrates that region-specific shocks and aggregate shocks should be included when trying to analyze the situation of local housing markets.

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