RESEARCH REPORT

Housing Price Variations in Canada

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Housing Price Variations in Canada

Final Report

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SUMMARY

The marked growth in housing prices in Canada since the beginning of the 21st century drew the attention of analysts and researchers who wanted to better understand the origins of these fluctuations, their dynamics and their impact on the performance of the global economy. This study falls within the scope of this objective and seeks to explain housing price variations in Canada nationally, as well as in large metropolitan areas. It takes into consideration the factors acting on both supply and demand.

More specifically, we primarily tried to determine and analyse the dynamic reaction of real housing prices when in the face of shocks to the key determinants, and to assess the relative importance that each one had in historic housing price variations. These assessments take into account the dynamic feedback between the residential real estate market and the rest of the economy. They are not, therefore, measurements of the direct impact of the various determinants on housing prices. We also explored a related question that our approach allowed us to address. It concerns the effects of real property wealth that housing price fluctuations imply on household spending and, more broadly, on the level of economic activity in the regions considered.

We will present a fairly comprehensive review of recent empirical literature on the determination of housing prices, particularly literature relating to metropolitan areas or addressing some of the themes with which we were dealing. One conclusion emerges. Recent studies leaned heavily toward using, as an analytical framework, either error correction models when it was studying the determinants' direct effects, or vector autoregression (VAR) models when it was analyzing the different determinants' dynamic impact in a systemic context.

Our analysis uses quarterly data for the period from 1972 to 2003 nationally, and 1975 to 2003 for urban agglomerations. We built a database containing the statistical series relevant to our study. Constraints were numerous, both with regard to the availability of data in metropolitan areas and the historical breaks in these statistical series. This database is a valuable contribution of this project.

Our empirical analysis framework is a vector autoregression (VAR) model. The reference VAR model contains six endogenous variables or determinants: real housing price, housing starts, employment, real interest rate, inflation and real construction costs. Variant reference models also include real land cost, the TSX stock market index and real retail sales. The metropolitan area estimations are probably sensitive to our sample's limited size. To overcome this problem, we performed a panel estimation of the metropolitan areas as a whole. It served as a basis for comparing the results of the estimations specific to each of the urban centres.

The national findings proved to be relatively precise and most interesting, demonstrating that monetary shocks (or real interest rate) are the primary historical determinant of housing price variations in Canada over the period under consideration. Monetary shocks explain roughly 22 % of the variations. More surprising is inflation's very powerful contribution—15 % in our preferred model. The impact of inflation on housing prices is clearly negative. In the recent context of stable, low inflation, one might expect that real housing prices would tend to be more stable and see higher growth. Employment shocks, contributing to 11 % of variations in real

housing prices, prove to be an important determinant, but weaker than anticipated at the outset. Lastly, the two supply factors considered, housing starts and real construction costs, are minor determinants, according to our findings.

In some complementary estimates, we see that unanticipated variations in land costs are probably a major determinant of housing prices, as shown by the estimated 25 % contribution. Like Sutton (2002), we also obtain a significant contribution by stock market shocks (14 %). However, we are presenting some arguments suggesting that this is an inflated assessment.

As far as the analyses of the metropolitan areas are concerned, our findings show that different urban centres display sensitivity to different shocks, and, in several cases, this sensitivity appreciably varies substantially from one agglomeration to another. The same result is observed with regard to the significance of various shocks in explaining historical variations in housing prices. Generally speaking, the findings in the metropolitan areas suggest that inflation is the dominant factor in most urban centres. As for Canada, the impulse responses indicate a negative impact of inflation shocks on variations in real housing prices. The contribution of monetary shocks is significant, but weaker than it is at the national level. A surprising element is the weak contribution of employment as a determinant. This weak influence is counterbalanced by a greater role for housing starts. Lastly, as for Canada, construction costs play a minor role in metropolitan areas.

In terms of dynamic effects, in all our findings we noted the long time intervals entailed in monetary shocks and the persistent, amplified reaction in housing prices and housing starts to their specific shocks. These characteristics suggest that the real estate market tends to overreact to shocks and takes a long time to recover its equilibrium. This stylized fact is entirely compatible with the presence of bubbles in the housing market.

In terms of the dynamic effects of shocks, it is possible to make some comparisons between metropolitan areas. The similarities stem primarily from geographical logic. Hence, the Calgary and Edmonton areas often exhibit similar impulse responses, as do Montréal and Québec City. Halifax and Ottawa-Gatineau tend to behave in ways similar to Montréal and Québec City. In certain aspects, Toronto and Hamilton exhibit similar dynamics. Finally, Vancouver’s impulse responses differ the most from the behaviours of other urban centres. Nevertheless, different urban centres display dynamic housing price behaviours that are in many regards unique to them.

SOMMAIRE

La croissance marquée des prix des logements au Canada depuis le début des années 2000 a attiré l'attention des analystes et des chercheurs qui ont voulu mieux comprendre les sources de ces fluctuations, leur dynamique et leur incidence sur la tenue de l'économie globale. La présente étude s'inscrit dans cet objectif. Elle vise à expliquer les variations des prix des logements au Canada, tant au niveau national qu'au niveau des grandes régions métropolitaines. Elle prend en considération à la fois les facteurs qui agissent sur l'offre et ceux agissant sur la demande.

Plus spécifiquement, nous avons principalement cherché à déterminer et à analyser la réaction dynamique des prix réels des logements face à des chocs sur les principaux déterminants et à apprécier l'importance relative de chacun d'eux dans les variations historiques des prix des logements. Ces évaluations tiennent compte des rétroactions dynamiques entre le marché immobilier résidentiel et le reste de l'économie. Elles ne sont donc pas des mesures de l'impact direct des divers déterminants sur les prix des logements. Nous avons aussi exploré une question connexe que notre approche permettait d'aborder. Elle concerne les effets de la richesse immobilière qu'impliquent les fluctuations des prix des logements sur les dépenses des ménages et, plus largement, sur le niveau de l'activité économique des régions considérées.

Nous présentons une revue relativement exhaustive de la littérature empirique récente concernant la détermination des prix des logements, notamment celle qui s'inscrivait au niveau des régions métropolitaines ou qui abordait des thèmes que nous traitions. Une conclusion s'en dégage. Les études récentes ont eu fortement tendance à utiliser, comme cadre d'analyse, soit des modèles à correction d'erreur lorsqu'il s'agissait d'étudier les effets directs des déterminants, ou encore des modèles d'autorégression vectorielle (VAR) lorsqu'il s'agissait d'analyser la question de l'incidence dynamique des divers déterminants dans un contexte systémique.

Notre analyse utilise des données trimestrielles couvrant la période 1972-2003 au niveau national et 1975-2003 au niveau des agglomérations urbaines. Nous avons constitué une base de données regroupant les séries statistiques pertinentes à notre étude. À cet égard, les contraintes étaient nombreuses, tant en ce qui concerne la disponibilité des données au niveau des régions métropolitaines qu'en ce qui a trait aux discontinuités historiques dans ces séries statistiques. Cette base de données constitue une contribution importante de ce projet.

Notre cadre d'analyse empirique est un modèle d'autorégression vectorielle (VAR). Le modèle VAR de référence comprend six variables endogènes ou déterminants. Ce sont : le prix réel des logements, les mises en chantier, l'emploi, le taux d'intérêt réel, l'inflation et les coûts réels de construction. Des variantes du modèle de référence font aussi intervenir le coût réel des terrains, l'indice boursier TSX et les ventes réelles de commerce de détail. Les estimations au niveau des régions métropolitaines sont probablement sensibles au problème de la taille limitée de notre échantillon. Pour contourner ce problème, nous avons fait une estimation *panel* sur l'ensemble des régions métropolitaines. Elle a servi de base de comparaison pour les résultats des estimations portant sur chacun des centres urbains.

Les résultats au niveau national s'avèrent des plus intéressants et relativement précis. Il ressort que les chocs monétaires (ou de taux d'intérêt réel) constituent le principal déterminant historique des variations des prix des logements au Canada sur la période considérée. Ils expliquent environ

22 % des variations. Plus surprenante est la contribution très forte de l'inflation qui s'élève à 15 % dans notre modèle préféré. L'incidence de l'inflation sur les prix des logements est clairement négative. Dans le contexte récent d'une inflation faible et stable, on peut croire que les prix réels des logements auront tendance à être plus stables et à connaître une croissance plus élevée. Les chocs d'emploi, avec une contribution de 11 % aux variations des prix réels des logements, s'avèrent un déterminant important, mais plus faible qu'anticipé au départ. Enfin, les deux facteurs d'offre considérés, les mises en chantier et les coûts réels de construction, constituent des déterminants mineurs selon nos résultats.

Dans des estimations complémentaires, nous observons que les variations non anticipées des coûts des terrains sont probablement un déterminant majeur des prix des logements comme en fait foi la contribution estimée de 25 %. À l'instar de Sutton (2002), nous obtenons aussi une contribution importante des chocs boursiers (14 %). Cependant, nous présentons des arguments qui incitent à penser qu'il s'agit d'une évaluation gonflée.

En ce qui concerne les analyses au niveau des régions métropolitaines, nos résultats montrent que les divers centres urbains affichent une sensibilité aux différents chocs qui, dans plusieurs cas, varie de manière appréciable d'une agglomération à l'autre. Même constat en regard de l'importance des divers chocs dans l'explication des variations historiques des prix des logements. De manière générale, les résultats au niveau des régions métropolitaines suggèrent que l'inflation constitue le facteur dominant, dans la plupart des centres urbains. Comme pour le Canada, les réponses dynamiques indiquent une incidence négative des chocs d'inflation sur les variations des prix réels des logements. La contribution des chocs monétaires est importante, mais plus faible que celle au niveau national. Une surprise est la faible contribution de l'emploi comme déterminant. Cette faible influence est contrebalancée par un rôle plus grand des mises en chantier. Enfin, comme pour le Canada, les coûts de construction jouent un rôle mineur au niveau des régions métropolitaines.

Sur le plan de la dynamique des effets, dans tous nos résultats, nous remarquons les longs délais qu'impliquent les chocs monétaires et la réaction amplifiée et persistante des prix des logements et des mises en chantier face à leurs propres chocs. Ces caractéristiques suggèrent que le marché immobilier ait tendance à surréagir aux chocs et qu'il tarde à retrouver son équilibre. Ce fait stylisé est tout à fait compatible avec la présence de bulles dans le marché des résidences.

Concernant les effets dynamiques des chocs, il est possible de faire certains rapprochements entre régions métropolitaines. Les similitudes tiennent principalement d'une logique géographique. Ainsi, les régions de Calgary et d'Edmonton exhibent souvent des réponses dynamiques semblables. Montréal et Québec aussi. Halifax et Ottawa-Gatineau ont des comportements qui ont plutôt tendance à se rapprocher de ceux de Montréal et Québec. À certains égards, Toronto et Hamilton exhibent une dynamique voisine. Enfin, Vancouver exhibe des réponses dynamiques qui se distinguent le plus de ceux des autres centres urbains. Il demeure que les divers centres urbains affichent des comportements dynamiques des prix des logements qui à plusieurs égards leur sont propres.

TABLE OF CONTENTS

1. INTRODUCTION

After a marked declined during the first half of the 1990s, housing prices in Canada have experienced accelerated growth since the beginning of the 21st century. How can these movements be explained? What factors played an important role in these fluctuations? These are questions of interest. As well, there are some who worry about a real estate price bubble and about the effects its implosion may produce. What is the real situation? Unfortunately, there are few recent empirical studies concerning the determinants of housing prices in Canada on which we can rely to answer these questions.

Furthermore, notable differences are observable in changes to real housing prices in Canada's different urban agglomerations (see Figure 1). Is it possible to explain these differences? Are these differences the result of a different housing price reaction to disturbances in the fundamental determinants, or do they stem from divergent economic conditions? Empirical studies that would enable us to answer these questions are practically non-existent in Canada. Because of the significance of the real estate market on the Canadian economy, its urban centres and Canadian households, it is important to take an interest in housing price behaviours and to learn more about the subject.

This study seeks to shed light on these important questions. We will attempt to explain the housing price variations in Canada's large metropolitan areas for the period from 1972 to 2003. At the same time, for comparison purposes and because the subject is of interest, we will also study national housing price fluctuations. More specifically, our objective will be to analyse the dynamic reaction of housing prices in the face of shocks to their primary determinants and to assess the relative importance of each of them for explaining historic variations in both national and metropolitan area housing prices. In our analysis, we will consider factors that act on demand as well as those that act on supply. Ten census metropolitan areas were selected for the purposes of our study. These urban centres are *Halifax, Québec City, Montréal, Ottawa-Gatineau, Toronto, Hamilton, Winnipeg, Calgary, Edmonton* and *Vancouver*.

We will look at two complementary questions. The first is the impact of the stock market on the growth of housing prices. To what extent have the recent boom in stock market wealth and the crash that followed affected housing prices in Canada and in major Canadian cities? Some recent studies have documented the effects of stock market wealth on household consumer spending, but few studies have examined its impact on housing prices. A recent study by Sutton (2002) suggests that stock market prices have been a very significant determinant of real housing prices in several countries, including Canada. We will examine this question.

Moreover, the rapid escalation of housing prices in recent years raises another question, the effect of this price surge, and the real property wealth it created, on household spending and more broadly, on the level of economic activity. This is the second complementary question we will address.

One of the important challenges in an empirical analysis of housing prices in metropolitan areas is that of building a statistical database. Constraints and obstacles are numerous, especially if we wish to cover a long enough period to perform a serious empirical analysis. Pertinent series are not always available. Those that are available often have historical breaks that need to be worked around. The building of this database is one of this project's significant contributions.

We will present a fairly comprehensive review of the recent empirical literature on housing price determinants, particularly literature relating to urban areas and literature that directly addresses the themes we are examining.

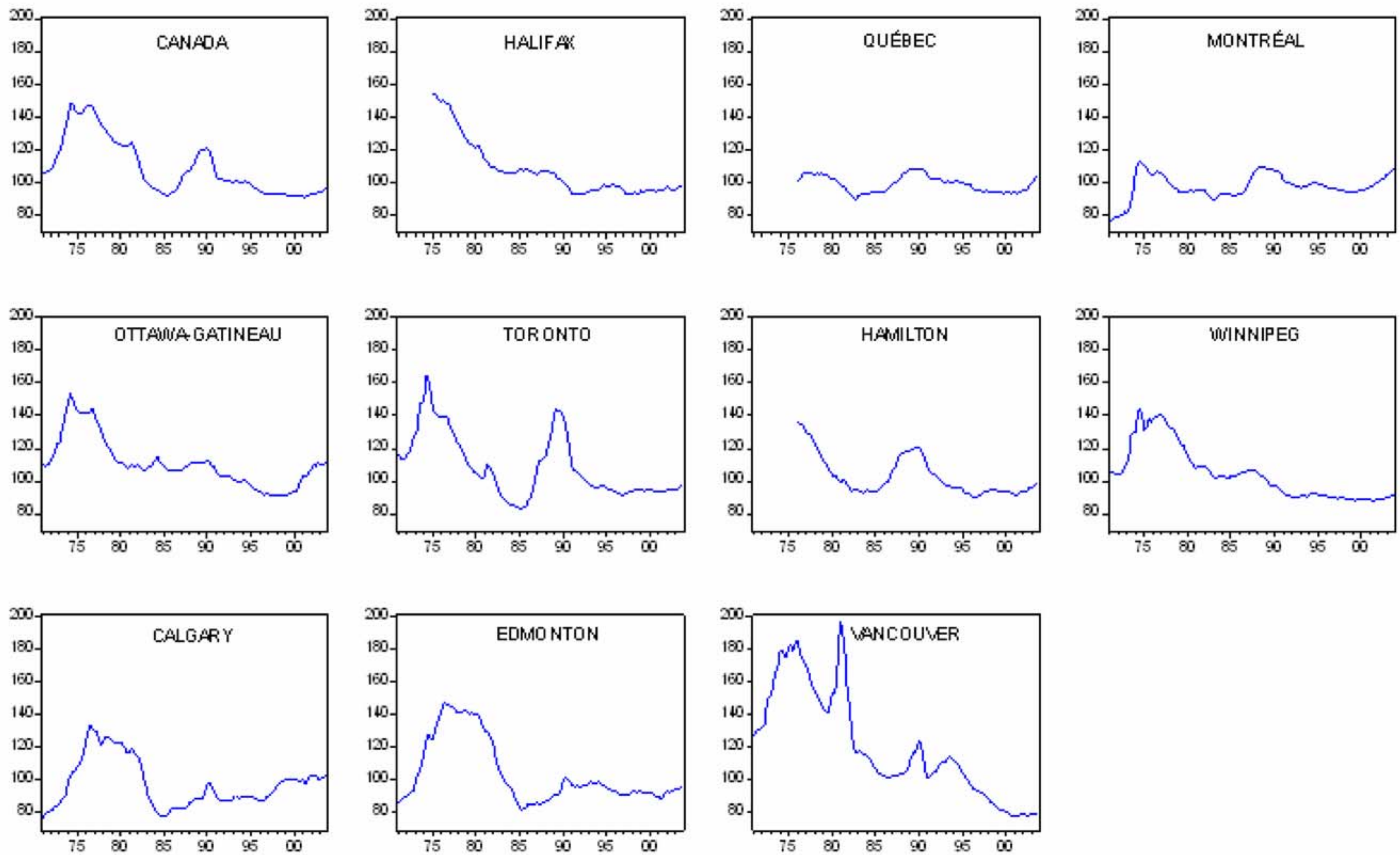
To study housing prices and to answer the questions asked, we used vector autoregression (VAR) methodology. This empirical analysis framework has the advantage of systematically capturing and using the rich dynamic interactions present in a group of statistical series. In our study framework, the variables are the primary determinants of housing prices. VAR proves to be even more appropriate in the context of our study since the real estate market exhibits complex and still poorly understood dynamics and, in urban areas, constraints related to the available statistics require pragmatism with respect to theoretical models. The VAR analysis will allow us to study housing price impulse responses to shocks in the determinants considered in our model and to estimate the contribution of these various determinants to historic variations in housing prices. Variants of the proposed VAR model will make it possible to explore the two complementary questions mentioned earlier.

The plan for the presentation is the following. Section 2 reviews the literature on housing price determinants. Sections 3 and 4 respectively present the vector autoregression methodology and the VAR model specification. The data are the subject of Section 5. The national empirical findings are presented in Section 6. A review of metropolitan area empirical findings follows in Section 7. Lastly, we draw our conclusions.

Figure 1
Trends in Real Prices for New Housing – Canada and Census Metropolitan Areas

FIGURE 1

Évolution des prix réels des logements neufs - Canada et régions métropolitaines de recensement



2. HOUSING PRICE DETERMINANTS: A REVIEW OF THE LITERATURE

There is abundant literature attempting to explain trends in housing prices.[1] In recent studies, the general theoretical framework is an extension of the life cycle consumption model and corresponds to a generalized general asset demand model in which housing is simultaneously seen as consumer goods and capital goods.[2] Within this general framework, several studies draw on the Poterba (1984) stock-flux model that simultaneously determines housing prices and construction levels. In this context, the equations determining real housing prices usually involve the following explanatory variables that are fundamental price determinants: real per-capita income, demographics, wealth, real immovable capital usage cost, housing stock and construction costs.[3]

These variables represent both supply and demand. All these variables are not always present and the measurements used can vary. Recent literature suggests a few useful clarifications:

(1) Theory presents the real cost of using immovable capital as an important determinant. Most often, it is measured by a real after-tax interest rate. The presence of borrowing constraints or monetary illusion might justify using a nominal interest rate. Empirically, some authors [(Malpezzi (1999); Meen (2001)] have shown that a nominal interest rate gave better results. Furthermore, Poterba (1984, 1991), Hendershott (1980) and Summers (1981) stress the interaction between taxation and inflation and, consequently, non-neutrality of inflation.[4] These arguments suggest that inflation may be a significant determinant of real housing prices.[5]

(2) Demographics and real per-capita income are two common determinants in housing price determination functions. Using total real income allows the population to be omitted as an explanatory variable for a restrictive hypothesis concerning the two variables' elasticity. Structural changes by age of population are also likely to have significant effects.[6]

(3) As explanatory variable, the housing stock (or its variation, basically housing starts)

[1] For a comprehensive review of the literature, the reader may refer to Smith, Rosen and Fallis (1988), Malpezzi (1990), Meen and Andrews (1998) and Meen (2001).

[2] Alternatively, the real housing price function may be presented as a smaller form of housing supply and demand functions. This usually leads to empirically equivalent specifications [Meen 2001].

[3] Real income is nominal income (in today's dollars) corrected to eliminate the effect of inflation. Real income is therefore income expressed in constant dollars of a base year. In the literature, several real income measurements are used, choice usually being guided by the statistical data available. The most relevant measurement, from a theoretical point of view, is real disposable income, i.e. household personal income, increased by transfers to persons and reduced by personal income tax.

[4] This argument has less impact in Canada than in the United States because of the non-deductibility of mortgage interest. However, capital gains earned on the primary residence are exempt in Canada, which constitutes a source of non-neutrality in relation to other forms of wealth retention.

[5] Empirical studies suggest that inflation was an important determinant of real housing prices in the 1970s and early 80s. See Kearns (1979), Smith, Rosen and Fallis (1988) and Meen (2001). Recently, Tsatsaronis and Zhu (2004), in a study focusing on real estate price dynamics in 17 countries, conclude that inflation constitutes the most important determinant of real housing prices.

[6] This was emphasized in the debate raised by the research of Mankiw and Veil (1989). For the Canadian case, see also Fortin and Leclerc (2000) and Engelhardt and Poterba (1991).

reflects the housing supply's adjustment capabilities. This variable is often absent from the specifications used. Meen (2001, p. 144) demonstrates that the effect of this omission is to exert a downward bias on the income elasticity of housing prices. Meen also shows that housing supply price elasticity is a crucial parameter for measuring the impact of different shocks on housing prices.

(4) Wheaton (1990) and Berkovec and Goodman (1996) suggest models that emphasize the interaction between real housing price and the volume of transactions. In their models, volume of transactions is used, among other things, to indicate the quality of information available to homebuyers (and sellers). A number of empirical studies used volume of transactions as a measurement of real estate activity [Berkovec and Goodman (1996), Stein (1995), Follain and Velz (1995), Hort (2000) and Meen (2000)].

(5) The wealth variable is most often absent from the empirical models used, and, these data are not always available. Some authors more specifically study the role of stock market prices as a determinant of housing prices [Quan and Titman (1999), Sutton (2002)].[7]

(6) Real construction cost measurements usually exclude land prices. Yet they are likely to have a significant impact on housing prices. Several studies took an interest in this question.[8] Some indicators of land availability or of the severity of environmental regulations with respect to urban development were tested as explanatory variables in metropolitan area housing price equations [Hendershott and Thibodeau (1990), Abraham and Hendershott (1996), Malpezzi (1999), Pryce (1999) and Capozza, Hendershott, Mack and Mayer (2002)]. Somerville (1996) shows the significance of land price in homebuilders' profits.

It is well documented empirically that disparities in housing markets exhibit great persistence [Smith, Rosen and Fallis (1988), Meen (2001)]. Thus, it is important to properly specify the adjustment dynamics. Several strategies can be used to do this. One approach is to assume there is a delay in housing supply adjustment by using a partial stock adjustment model. This has the effect of introducing the lagged dependent variable as explanatory variable. Models used by Summers (1981) and Wheaton (1990) are examples of this. Another approach consists of defining equilibrium values for housing prices (based on the fundamental determinants) and to specify a dynamic model bringing into play the disparity between equilibrium values and observed values. Many recent studies use this approach. This can be done specifically within the framework of error-correction models popularized by Hendry (1984). European studies that use this approach in great number [Hort (1998), Meen (2002) and Barot and Yang (2002)] are interesting examples of this. Several American studies also adopted this perspective without making explicit use of the error-correction model's estimation strategy [Abraham and Hendershott (1996), Malpezzi (1999), Lamont and Stein (1999) and Capozza, Hendershott, Mack and Mayer (2002)].

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[7] On a broader perspective, several recent studies attempted to measure the effect sizes of stock market wealth on household spending [Ludvigson and Steindel (1999), Lettau and Ludvigson (2001), Maki and Palumbo (2001) and Pichette (2001)].

[8] See Smith, Rosen and Fallis (1988) for an overview of the question.

A number of studies exist that have sought to explain the growth of real housing prices in metropolitan areas. Considering the purpose of our research, these are the studies that interest us at first sight. They are highly constrained by data availability. They are mostly American studies, as the United States has a more complete and more reliable set of data at this level of disaggregation. Since data is not available over an extended period, the vast majority of the studies use the panel approach, thereby forcing the real prices in the various urban agglomerations to have the same sensitivity to variations in the explanatory variables.[9] Consequently, evolutionary differences in real housing prices in different metropolitan areas are explained by the divergent evolution in the explanatory variables and not by differences of sensitivity to variations in the determinants. This limitation can involve bias. Obviously, if enough observations are available, we can overcome the problem since we can test the assumption of coefficient equality by metropolitan area and make the necessary corrections where needed.

Among recent studies, the best known and most cited is certainly the study by Abraham and Hendershott (1996).[10] It deals with 30 American urban agglomerations and uses annual data for the period from 1977 to 1992. They identify two groups of determinants: the first explains changes in the real equilibrium housing price, the second accounts for the dynamic adjustments — or deviations — in relation to the equilibrium price. Growth in real per-capita income and employment (in lieu of population), growth in real construction costs and variation in the real after-tax interest rates are the variables constituting the fundamental determinants. The endogenous variable lagged by one period (lagged inflation of real housing prices) and a slack variable between equilibrium prices and observed prices explain the dynamic adjustment. In its preferred model, these variables account for roughly 55% of the real housing price fluctuations in the 30 cities considered. Growth in per-capita income, growth in employment, construction cost inflation and variations in the real after-tax interest rate significantly affect the rise in housing prices in the short and the long term alike.[11] Lagged growth in housing prices, which represent the *momentum*, has a fairly high coefficient of 0.36. The disequilibrium variable has a coefficient of –0.14, indicating that the gap is slowly narrowing at a rate of 14% per year. But this is a mean; the model proves much more valuable for explaining the behaviour of cities in inland states and is far less valuable in accounting for housing price variations in cities of coastal states. The differences are primarily in the dynamic adjustment (the coefficients linked to the lagged endogenous variable and the disequilibrium variable) and the reaction to variations in real construction costs. This last finding concerning construction costs suggests a significant influence for land availability and/or urban development regulations in costal cities.[12]

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[9] A panel study handles several samples of chronological series in groups reflecting, for example, different regions or different countries.

[10] Among some slightly less recent studies that look at real housing price determinants in metropolitan areas, we mention studies by Nellis and Longbottom (1981), Ozane and Thibodeau (1983), Case and Schiller (1989, 1990) and Poterba (1991).

[11] Short-term and long-term elasticity is 0.46 and 0.73 for construction costs, 0.50 and 0.78 for real income, 0.35 and 0.54 for employment and –0.55 and –0.86 for real after-tax interest rate variation.

[12] Abraham and Hendershott interpret their findings in terms of the existence of speculative bubbles. The coefficient associated with the lagged endogenous variable would be a "*bubble-builder*" and the coefficient linked to the disequilibrium variable a "*bubble-burster*." Speculative bubbles would be more applicable to coastal cities, the disequilibrium variable not being significant. Meen (2001) argues that housing price deviations in relation to their equilibrium values do not necessarily imply the existence of speculative behaviour and may be compatible with other types of explanations, including the existence of transaction costs.

The Abraham and Hendershott model has definite similarities to an error-correction model even though the estimation strategy is different. This is also the case of studies by Malpezzi (1999) and Capozza, Hendershott, Mack and Mayer (2002). The Malpezzi (1999) study deals with a panel of 133 metropolitan areas covering 17 years (1979-1996). He assumes a long-term equilibrium relationship (*cointegration* in the jargon of error-correction models) between real housing prices and real per-capita income, which enables him to define a series of equilibrium prices. His model explains the growth of real housing prices based on the error-correction term (disequilibrium variable) and growth in real per-capita income, population and mortgage interest rates. We note here the absence of construction costs and housing stock. Malpezzi's key finding is that the level of environmental regulation of urban development constitutes an important determinant of the long-term housing price ratio and significantly influences the rate of adjustment toward equilibrium price. The stricter the regulations, the slower the rate of dynamic adjustment. For the other housing-price determinants, population proves to have a much larger (positive) effect than income. Furthermore, interest rates, which have a significant adverse effect, provide more interesting results when expressed in nominal terms, which is an indication of the role played by borrowing constraints.

For their part, Lamont and Stein (1999) tried to explain the differences in dynamic behaviours of real housing prices in 44 urban agglomerations in the United States during the period from 1984 to 1994. Three variables explain 74% of the evolution in housing prices. These are growth in real per-capita income, population growth and the *Housing price/Real per-capita income* ratio lagged by one period. With this model, these authors show that areas that have, on average, a high mortgage borrowing rate (in relation to housing price) react more strongly to demand shocks. This finding is consistent with recent theories that highlight the role of borrowing constraints.

More recently, Capozza, Hendershott, Mack and Mayer (2002) studied housing price determinants in 62 U.S. metropolitan areas for the period from 1979 to 1995. They empirically evaluated what affected persistence (the effect of lagged housing prices or *momentum*) and the rate of adjustment toward long-term equilibrium. Essentially, they examined the cyclical behaviour of housing prices. The variables considered were population, median real income, capital usage cost and real construction costs.[13] Their findings show that discrepancies observed in the evolution of real housing prices cannot be explained solely by different local conditions. They react differently to various economic shocks, depending on the rate of population growth in the area, the rate of real income growth, the size of the area (population and income levels) and the level of construction costs. Hence, areas with strong growth (income and population) have housing prices that are more sensitive to economic shocks and exhibit greater persistence; areas that have higher construction costs experience greater *momentum*, but adjustment toward

[13] These variables are customary in housing price functions. However, the authors take a different approach to justifying their existence. Building on the Wheaton (1990) and DiPasquale and Wheaton (1996) models, the urban agglomeration's population size and median income are used as indicators for measuring information costs and transaction volume. Construction cost measures, for its part, factors that reduce short-term supply elasticity, in particular, the strictness of environmental regulations. Growth in real income and underlying population growth help measure the role of inertia or historical expectations.

equilibrium is slower. Consequently, they also experience greater cyclical real housing price volatility.[14]

Among the non-American studies, we adopt the study by Hort (1998). The author analyses the determinants of annual housing price variations in 20 urban areas in Sweden over the period from 1967 to 1994. She uses an error-correction model assuming a long-term relationship between housing prices, real income, real interest rate, population and construction costs. When compared with the studies by Abraham and Hendershott for American urban centres, Hort's Swedish results indicate that real housing prices in the United States are much more sensitive in the short term to changes in supply and demand than in Sweden, but that the adjustment toward long-term equilibrium is much slower in the United States.

To our knowledge, few Canadian studies have sought to identify and measure the significance of housing price determinants in major Canadian cities. Fortura and Kushner (1986) attempt to explain housing price differentials in large Canadian cities with the help of cross-sectional data. They show that factors of demand such as real income are major housing price determinants. Expected inflation also proves to be a significant positive influence on housing prices. Capozza and Schwann (1989) test the Capozza-Helsley model (asset-demand model emphasizing land prices) with Canadian annual data for 20 metropolitan areas over the period from 1969 to 1984. Their findings indicate that the level of new housing prices is substantially connected to the number of households, the anticipated number of housing construction completions, the nominal interest rate and the real after-tax interest rate. We note the absence of any income indicator as explanatory variable. More recently, Jim Clayton (1996) tested a Poterba-type of housing price determination model with rational expectations using annual data for the Vancouver area from 1979 to 1991. His tests refute the rational expectations assumption.[15] The model fails to accurately track housing price dynamics during real estate booms, but does a fair job of tracking the evolution of real housing prices in periods with less volatility.

Recourse to a single equation model for explaining housing price evolution has some weaknesses. The explanatory variables are assumed to be exogenous and do not take into account the possibility of feedback from housing prices to these explanatory variables. However, Meen (2001) shows the importance of this systemic feedback in obtaining an accurate assessment of the significance of factors at the origin of housing price fluctuations. Another piece of evidence — several recent studies show the extent to which evolution in housing prices affects the global economic cycle. Thus, Case, Quigley and Shiller (2001), Girouard and Blöndal (2001), Desnoyers (2001), Boone and Girouard (2002) and OECD (2004) show that real property wealth has a much more significant effect on household spending than wealth held in other forms. This conclusion also holds for Canada [Pichette and Tremblay (2003)]. Moreover, housing price variations, particularly in a context of declining interest rates, can modify the transmission of monetary shocks by relaxing liquidity constraints. Several recent studies on this theme emphasize

[14] Gallin (2003) criticizes all these studies that use an error-correction specification. His cointegration tests, carefully applied to American data at national and metropolitan area levels alike (panel data), do not prove the very existence of long-term relationships. He therefore concludes that error-correction specifications might be inappropriate and the results obtained biased.

[15] The rational expectations assumption is a theory by which economic agents use all available information to anticipate the future. Its implications are that there cannot be any systemic forecasting errors in it and that the markets operate efficiently.

the effects of waves of mortgage refinancing on the economy [Aoki, Proudman and Vlieghe (2001), Brady, Canner and Maki (2000), Canner, Dynan and Passmore (2002), Girouard and Blöndal (2001), Deep and Domanski (2002) and CMHC (2004)]. Monetary policies themselves may be impacted by changing housing prices, especially in a policy framework targeting inflation [see Dodge (2003) and Meen (2000)]. Evaluating the impacts of the various housing price determinants without considering the possibilities of feedback exposes us to measurement errors. Meen's observation (2001) confirms these fears, "*The moral is that systems properties matter, whereas single equation results can be highly misleading. . . . Therefore it does not appear to be the case that cycles [in real house prices] are caused only by factors exogenous to the housing industry, but are an intrinsic feature of the sector*."

One way of broadening the analysis framework to better accommodate system feedback is to study housing price determinants using vector autoregression (VAR) models.[16, 17] This is what is proposed by Baffoe-Bonie (1998), Lastrapes (2002), McCarthy and Peach (2002), Sutton (2002) and Tsatsaronis and Zhu (2004). The Baffoe-Bonie study deals with national and regional U.S. data. It analyses the effects of four macroeconomic variables on housing prices and inventory: employment, mortgage interest rate, money supply and the consumer price index.[18] It shows that the real estate market is very sensitive to the mortgage interest rate and to employment growth at both the national and regional levels.[19] Furthermore, it turns out that housing prices in different areas react differently to different shocks and that economic aggregates do not adequately explain fluctuations in housing prices and construction in certain areas.

Lastrapes (2002) proposes a VAR model that involves real housing prices, home sales (new and existing), money supply, yield rate on three-month Treasury Bills, the long-term mortgage rate, industrial production and a raw materials price index. His study uses American national monthly data from 1963 to 1999. Particular attention is paid to identification assumptions in analysing impulse response functions to various shocks. His empirical model, although distinctive in its choice of variables, makes it possible to highlight the different channels through which monetary policy affects housing prices.

McCarthy and Peach (2002) focus on the monetary policy's transmission to the residential construction sector and, in particular, on the impact that deregulating the financial system had on housing market behaviour in the United States. Their conclusions are: (1) that monetary policy has a slower initial impact on housing investment in the context of a deregulated banking market but, on the other hand, housing prices react more promptly, and (2) that housing demand is now much more dependent on demand factors. They arrive at these findings using two approaches. Initially, they consider a VAR system retaining the following seven endogenous variables: real gross domestic product (GDP), GDP deflator, price of raw materials, investment in residential construction, real housing price, yield rate on federal funds and a mortgage rate. Secondly, they more fully examine the how and why of changes in the monetary policy's dynamic effects with a

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[16] VAR methodology will be explained in another section of this document.

[17] Alternatively, the real estate sector models could be integrated into a broader macroeconomic model. One problem with this approach is that the results depend as much on the properties of the econometric model as on the structure of the housing market model [Meen (2001)].

[18] Actually, all these variables are expressed as growth rates in the VAR model, except for mortgage interest rate.

[19] The simultaneous presence of money supply and mortgage interest rate causes some problems in identifying the different shocks. Some impulse responses are not very plausible.

structural model of the housing market in the form of two error-correction equations, one corresponding to housing supply and the other to housing demand. The variables in these dynamic supply and demand equations are fairly standard, except that consumption serves as the indicator for permanent income.

Sutton (2002) takes a direct interest in housing price determinants in five countries, including Canada. His model appraises quarterly data from 1973 to 2002. His VAR model, applied to each of these countries, contains four endogenous variables: real housing prices, real national income, real interest rate and stock market prices. One astounding finding is that, in most of the countries, stock price fluctuations play as important a role in the period from 1995 to 2002 as do variations in interest rates and national income.[20] At first glance, Sutton's findings do not seem strong. They would benefit from being corroborated by other studies. For Canada, Sutton's study raises an additional question: how to explain the difficulty his VAR model has in predicting the recent upsurges in housing prices.

More recently, in the wake of the Sutton study (2002), Tsatsaronis and Zhu (2004) used a VAR model to analyse the dynamics of real estate prices in 17 countries. Besides real housing prices, they use the endogenous variables of GDP growth rate, inflation, real short-term interest rate, the slope of the yield curve (the difference between a long- and a short-term rate) and bank credit expansion (in real terms). Their analysis primarily reveals the dominant effect of inflation on real housing prices and the impact of certain characteristics of the national mortgage markets. Another finding, household income measured by the GDP, has only a minor impact on variations in housing prices.

One definite advantage of VAR modelling is that it permits analysis of feedback between the real estate market and the rest of the economy without having to specify and consider a full structural model of the economy. In addition, VAR technology lets the data define the interactions' dynamics without imposing *a priori* restrictions, unlike structural models. This is also their main limitation. To analyse the impulse response paths associated with different types of shocks, some identification assumptions must be made.[21] The responses obtained are often very sensitive to the assumptions retained. To overcome this problem and be able to give a structural interpretation to the coefficients considered, we can make use of a particular class of vector autoregression model, i.e. vector error-correction models (VECMs). They are the "equation system" counterparts of error-correction models. This type of modelling is used by Meen (2000). He develops a VECM model compatible with the Poterba (1984) stock-flux model. Four endogenous variables are part of the VECM. They are housing starts, housing price, short-term interest rate and construction costs. Two cointegration ratios (or long-term ratios) anchor the dynamic adjustments. His model explains the international differences observed in the real housing price trend, as well as the cyclical properties of the housing market variables. His findings confirm the importance of analysing the evolution of housing prices from a system of equations rather than with a single equation.[22]

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[20] For Canada, the United States and Australia, these three determinants would each explain between 7 and 15% of the evolution of housing prices. In the United Kingdom, stock price fluctuations would account for 35% of the variations in housing prices.

[21] For an intuitive explanation of the shock identification problem, the reader may refer to Section 3.3 on the limitations of the vector autoregression approach.

[22] Meen (2002) proposes a variant of his VECM model for studying the relationship between housing prices and

We have presented a review of those studies on housing price determinants that appeared most relevant with regard to the purpose of our work. The recent literature has made extensive use of an error-correction model (single equation) type of modelling or vector autoregression (system of equations) modelling. Until now, error-correction models were preferred for analyses at the metropolitan area level. Because of the statistical series available, covering relatively short periods, estimates were applied above all to panels of metropolitan areas. The VAR modelling was used more often for analyses at the national or international level. Its application to the study of housing price dynamics is very recent. This approach requires a great many observations, however, which has prompted several researchers to focus their analyses on panels of countries. Available data permitting, nothing prevents applying VAR methodology to metropolitan areas or to panels of metropolitan areas. This is what we propose to do. But first, we will present the vector autoregression approach and discuss its advantages and its limitations in the section that follows.

3. VECTOR AUTOREGRESSION METHODOLOGY

Our primary objective in this project is to explain the housing price variations in 10 major urban centres. To measure the effect of the various factors and to clarify their dynamics, we are using the vector autoregression method, commonly called VAR.

3.1 What is vector autoregression (VAR)?

A VAR model is a system of equations where all the variables are endogenous, which is to say, explained by the model. Each variable can be expressed as a linear function of its own lagged values, as well as of the lagged values of all the other variables in the system. An error term completes each equation. The approach requires only a minimal contribution of economic theory. This contribution may, above all, help guide the choice of the system's endogenous variables. In the case that interests us, besides housing prices, the variables will reflect housing price determinants. We will return to this later.

This type of macroeconomic modelling was initially proposed by Christopher Sims (1980) and has been widely used since then for data characterization, forecasting, structural inference and policy analysis (Stock and Watson, 2001). The primary objective of the current project essentially relates to structural inference. We are interested in the impulse response of certain variables in the model following shocks in the endogenous variables, as well as in explaining the variables' historical variations in terms of these shocks.

3.2 Advantages of VAR methodology

VAR models are simple frameworks for systematically capturing the wealth of dynamic feedback between the variables present in an array of chronological series. Traditional structural models impose a very large number of restrictive assumptions on these interrelations. These restrictions are often debatable and are rarely empirically validated. VAR methodology has the advantage of retaining a smaller number of restrictive assumptions and of allowing the data, rather than the

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transaction volume.

researchers, to determine the configuration of these dynamic relationships between the model's variables. A VAR can be seen as a general dynamic system having several existing structural models as specific cases.

In a context where the various theoretical models are not properly validated empirically, where these models most often have very little to say concerning the relationships' dynamics and where the available data do not always perfectly fit the variables suggested by the theory, it is prudent to minimize the imposed restrictive assumptions and allow the data to express themselves.

In the real estate market, it is common knowledge that the dynamics are complex, quite poorly understood and very different from the dynamics of other markets. There is a great risk of retaining unfounded restrictive assumptions. Particularly in this case, VAR constitutes an ideal approach. Furthermore, in terms of metropolitan areas, the scarcity of statistical series forces us to distance ourselves from theoretical models. Here again, VAR methodology can prove to be a most useful approach because of its great modelling flexibility.

Furthermore, VAR methodology comes with its own toolbox, instruments well-grounded in statistical theory and relatively easy to use. These tools allow us to directly answer the questions we want to answer within the framework of this project. Therefore, in reference to our project, the impulse response functions allow us to measure the effects on housing prices of shocks associated with the different determinants. Variance decomposition allows us to measure the contribution of these different shocks — and therefore the determinants — to the explanation of historical housing price variations. All in all, the VAR approach is a flexible, consistent, credible and effective methodology. It is particularly appropriate with respect to this project's objectives.

3.3 Limitations of the VAR approach

Like any other methodology, the VAR approach has some limitations and usage challenges. This is particularly the case when it is used for structural inference purposes (Stock and Watson 2001).

The primary problem in this regard is shock identification. The estimated error terms in the different equations of the VAR model cannot be interpreted as shocks attributable to their corresponding endogenous variable. Why? Because a shock can affect the residuals of several variables at the same time. For example, if the Bank of Canada establishes its guide rate on the basis of current inflation and employment developments, the interest rate, inflation and employment equations' error terms will be connected, will contain common parts. Before considering the impulse responses and performing variance decomposition, it is necessary to distribute the common parts of the residuals amongst the various variables, in other words, to properly identify the shocks specific to each of them. Variations in these decomposed residuals are structural shocks connected exclusively to one or the other of the VAR model's endogenous variables. Therefore, to correctly evaluate the housing price variations that arise from the shocks corresponding to real interest rate, inflation and employment, we must decompose the estimated residuals, with the help of identification assumptions. The results will depend on the selected identification assumptions. This problem is inherent and cannot be solved solely with statistical tools. It is necessary to refer to economic theory and institutional knowledge to resolve this identification problem.

Another problem relates to the choice of variables present in the VAR. The error terms in a VAR system, as in conventional regressions, reflect the factors that were not taken into account in the model. If these omitted factors are correlated with the variables present in the model, then the VAR estimates contain a variable omission bias. This bias will have repercussions on the impulse response estimates. This potential problem and the need to properly identify structural shocks prompt us to specify our VAR model on the basis of a coherent theoretical framework of determinants of variations in real housing prices.

The VAR approach, because it is not a particularly discretionary modelling (minimal number of restrictions), is demanding in terms of the number of observations. For this reason, the number of variables to be included in the model needs to be limited. Increasing their number exponentially multiplies the number of parameters to be considered. Very quickly, uncertainty surrounding the estimates will grow. Thus, the number of variables present in the VAR must remain limited. On the other hand, a very small VAR system of two or three variables, for example, sometimes leads to unstable estimates, presents difficulties in interpreting the structural shocks it identifies, and does not allow us to consider all the major determinants (Stock and Watson, 2001). Therefore, we have to deal with this arbitrage in such a way that our VAR model is effective and efficient.

Vector autoregression

The mathematical depiction of a VAR system is as follows:

$$y_t = A_1\, y_{t-1} + A_2\, y_{t-2} + \ldots + A_p\, y_{t-2} + \varepsilon_t$$

where y_t is an endogenous variables vector,
$A_1 \ldots A_p$ are the coefficient matrices to be estimated
ε_t is an error-terms vector.

The lag number p is determined by one or more statistical criteria. The error terms in each equation possess certain desirable properties from the perspective of estimation.

The VAR is completed by shock identification assumptions. The various equations' error terms are generally intercorrelated. In this situation, error terms vector ε_t cannot be interpreted as shocks on determinants y_t. The error term in each VAR equation is instead a linear combination of shocks specific to the different endogenous variables composing the VAR; these specific shocks are not known beforehand. To identify the shock specific to each of the VAR system's endogenous variables, it is necessary to decompose the ε_t residuals. This is done using identification assumptions. Different identification assumptions can lead to different empirical results.

Several approaches are used to achieve identification. The most common approach that has proven itself consists of ranking the VAR variables on the basis of our *a priori* knowledge of each variable's immediate effects on the other variables in the model. This is the [residual variance triangulation] method. It is the approach we favour in this study.

4. SPECIFICATION OF THE VAR MODELS

In the preceding section, we provided a general description of the vector autoregression approach and we justified its use with the framework of this project. We will now clarify the empirical analysis framework by discussing the choice of the variables that will form the VAR models, the estimation strategy and the identification assumptions retained for identifying structural shocks. In particular, it will deal with the issue of panel estimation. We will end the section with a discussion relating to interpreting the different shocks and impulse responses.

4.1 Choosing the constituent variables

The VAR modelling philosophy is to impose the fewest possible restrictions on the relationships between the model's variables, thereby permitting the data to express themselves. It is therefore an essentially statistical approach in which theory intervenes only to help identify the endogenous variables that will be part of the VAR model. There are no particular rules for this, and the number of possible VAR models is limited only by the authors' imaginations and by the subject under study. Generally speaking, in the literature, the authors restrict themselves to listing the VAR variables and justifying them very broadly on the basis of theoretical considerations. We have chosen to identify our VAR system's variables on the basis of a general real housing price determination model that is compatible with most of the models proposed in the literature.[23]

We will start with a long-term housing demand function connecting the number of housing units required (H^D) to the real housing price (PH) and to a variables vector (X) representing other housing demand determinants. In the literature on real estate economics, this demand function is usually derived from a life cycle model where consumers maximize their satisfaction within their intertemporal budget constraint.[24] In this context, real disposable income, real immovable capital usage cost and real household wealth are the variables that can form vector X. The literature is fairly precise as to what determines real usage cost. The cost of using immovable capital is influenced chiefly by changes in interest rates. Theoretically, the ideal measurement would be a real after-tax interest rate that would also take into account earnings expected from the immovable capital's appreciation [Meen (2001)]. In practice, empirical literature does not tell us whether a real or nominal interest rate should be used. The presence of liquidity constraints justifies using the nominal interest rate. If both are pertinent, inflation becomes a housing demand determinant.[25] Taxation's non-neutrality with regard to inflation [Summers (1981); Poterba (1989)] is another argument in favour of using inflation as a housing demand determinant.[26]

In metropolitan areas, empirical analysis is highly constrained by data availability. With regard to this, the temporal series on disposable income or other measurements of household income are too short to be used in this study. The same constraint exists for consumer spending, which some

[23] As a VAR model is a system of equations, we use the terms "model" and "system" interchangeably.
[24] An intertemporal budget constraint is a dynamic budget constraint that explicitly considers the possibility households have of borrowing against future income or saving to consume more in the future.
[25] Nominal interest rate can be defined as the sum of the real interest rate and the expected inflation rate, which is closely connected to recent changes in the inflation rate.
[26] Another argument frequently put forward stipulates that, in an inflationary context, households prefer to invest in more secure assets, better protected against inflation, which favours real estate investments.

authors have used in lieu of permanent income.[27] Retail sales prove to be a close indicator of consumer spending. Data for this variable are available for four census metropolitan areas (CMAs). Moreover, there is absolutely no data on household wealth in CMAs. However, changes in housing prices and stock market prices are two key components in assessing this wealth. The real housing price is already present in the theoretical model. The structure of the VAR will therefore implicitly accommodate the effect of real property wealth. The Toronto Stock Exchange index (TSX or TSE300), expressed in real terms, will track the effect of wealth associated with fluctuations in the value of stocks owned by households.[28]

On the basis of this discussion concerning the theoretical framework and constraints in CMA data availability, the VAR reference system will include the following variables:

- real housing prices;
- housing stock (in which the primary difference essentially reflects housing starts);
- employment or real retail sales (as indicator of economic activity or income);
- real interest rate (representing both mortgage financing costs and the direction of monetary policy);
- inflation rate;
- one (or more) construction cost measurement(s) (labour costs, material costs, land costs);
- a stock market price measurement, expressed in real terms.

All the variables are expressed as logarithms, except real interest rate and inflation rate.[29] For statistical inference purposes, it is preferable that the variables composing the VAR system be stationary. Therefore, when the variables identified are not stationary, they are made stationary using primary differentiation. Stationarity tests (called unit root tests) were performed on the statistical series retained.[30] They indicate that the real housing price, housing starts (especially housing stock), employment, real retail sales and real construction costs (whatever the measurement) have a unit root. These variables must be made stationary by differentiation. On the basis of inconclusive tests and economic theory, real interest rate enters in level in the VAR model.[31] The TSX stock market index, expressed in real terms, is stationary over the period studied and must therefore enter in level in the VAR.

The precise measurement of the variables in the VAR system is as follows:

- real housing price is measured by the New Housing Price Index (NHPI), corrected for inflation using the Consumer Price Index (CPI); percentage change (dlog);[32, 33]

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[27] As an example, see McCarthy and Peach (2002).
[28] This variable could also track a substitution effect operating between the various asset categories.
[29] In the literature, it is customary to express variables as logarithms, thus tracking a form of non-linearity present in the relationships between the dependent variables and their determinants.
[30] The results of these tests are presented in Appendix C.
[31] This choice has no significant impact on the results obtained.
[32] The prices of existing homes sold through the Multiple Listing Service (MLS) would have been an interesting measurement. Unfortunately, the series only starts in 1980, too short a time to accommodate the dynamics of the retained VAR system.
[33] Dlog (X) is the first discrepancy in the series X logarithm. This expression is a fairly accurate approximation of the

- housing starts (HS); percentage change (dlog);
- number of jobs (EMP'T); percentage change (dlog); or
- retail sales (SRETAIL), corrected for inflation using the CPI; percentage change (dlog);
- real interest rate is measured by the yield rate on three-month Treasury Bills (Y90), minus the CPI growth rate over the last twelve months;[34]
- inflation is measured by quarterly growth in the CPI (dlog);
- real construction costs are measured by: (1) a weighted labour cost index, and construction material costs (CC), corrected for inflation using the CPI and expressed in percentage change (dlog); (2) a land price measurement (LC) corresponding to a sub-index of the New Housing Price Index;
- the Toronto Stock Exchange TSX index (formerly the TSE300), corrected for inflation using the CPI; this variable is expressed in level in the VAR system by virtue of the stationarity test results.

4.2 Estimation strategy

The preceding discussion concerning the VAR system's specification suggests several possible variants of the VAR model for studying real housing prices. For the empirical work, we will adopt the following estimation strategy.

The reference model will contain the six following variables: real housing price (Δ% NHPI/CPI), housing starts (Δ% HS), employment (Δ% EMP'T), real interest rate (R90/100-[CPI/CPI_{-4} -1]), inflation (Δ% CPI) and total construction costs, excluding land costs (Δ% CC/CPI).

Variants of the reference model will consider:

(1) inclusion of land costs LC/CPI, in addition to total construction costs CC/CPI);
(2) use of real retail sales to measure activity levels, instead of employment (Δ% SRETAIL/CPI); and
(3) the addition of a seventh endogenous variable to the VAR model, the TSE300 index expressed in real terms (TSX/CPI).

In addition to the endogenous variables, each equation in the VAR system contains the following exogenous variables: a constant; three nominal variables representing seasonal effects, namely S1, S2 and S4; a trend variable (TREND) and a dichotomous variable, D911 assuming the value one (1) in the first quarter of 1991 and zero (0) otherwise, in order to account for the introduction of the Goods and Services Tax (GST) in January 1991. For all the VAR models considered, the lag number in the endogenous variables was set at four (see the justification further on).

percentage change of series X.

[34] As mentioned earlier, real interest rate represents both mortgage financing costs and the direction of monetary policies. Some authors simultaneously used two separate interest rate measurements in their VAR model, a short-term interest rate and a mortgage rate (for example, Baffoe-Bonnie [1998]). Unfortunately, this makes it very difficult to identify monetary policy shocks, a key element of real estate market dynamics. In this regard, a short-term interest rate is a better indicator of the direction of monetary policy.

The reference model and its variants were estimated nationally (Canada) and for each of the ten CMAs. The estimations use quarterly data over the longest period permitted by their availability. Hence, for the reference model and all the variants involving employment as endogenous variable, the estimation period starts in 1972Q1 (Canada) or 1975Q1 (start date of the series on employment in CMAs) and ends in 2003Q3. For the variant that makes use of the retail sales variable, the beginning of the estimation period is 1972Q1. In this case, the estimations refer to only four of the 10 metropolitan areas in addition to Canada.[35]

4.3 VAR panel estimation

The VAR model we retained has six variables in its basic version. This number involves the estimation of a substantial number of coefficients. We have already mentioned that this is not without its problems, considering that the statistical data sample available for the estimation is limited to 115 observations in most of the cases. This implies that the impulse responses will be estimated with less precision. Furthermore, these dynamics have a greater chance of being biased by major but accidental fluctuations in the statistical series. Normally, when the number of observations is high in relation to the number of coefficients to be estimated, the estimation methods succeed in eliminating these undesirable accidental fluctuation effects. In the context of our study, the risks of bias are significant. The fact that the statistical series used relates to a high level of disaggregation (the CMAs) exacerbates this problem.

Not much can be done to circumvent this problem. One possibility is to consider a common VAR model by grouping the samples from the 10 metropolitan areas and treating the areas as a whole. This approach is called an "*estimation panel*" or "*VAR panel*". It requires that the data be structured in a particular fashion. One implication is that the VAR panel's dynamic structure will be the same for all the metropolitan areas. Therefore, evolution differences between CMAs will result solely from the fact that the shocks that disturb the various CMAs are different or of unequal size. By using this strategy, we find ourselves with more than a thousand observations, instead of about a hundred.[36] This allows us to reduce the impulse response confidence intervals. In addition, panel estimations constitute a point of reference with which it is possible to compare the results obtained for each metropolitan area.

Thus, a VAR *panel* of the 4^{th} order (four time intervals for each of the system's variables) was estimated. Application of the analysis tool is the same as for a traditional VAR.

4.4 Estimation technique and diagnostic tests

The VAR and VAR panel models' equations were estimated by the ordinary least squares method using EViews 5.1 software.[37] Not having any immediate structural interpretation, the estimated coefficients will not be presented. As is customary, only the impulse responses and the results of variance decompositions will be presented.

[35] Remember that CMA retail sales statistics are only available for four CMAs, namely Montréal, Toronto, Winnipeg and Vancouver.

[36] Recently, Gavin and Theodorou (2003) proposed and used the VAR panel method to reduce sampling errors.

[37] Since the right-hand variables in a VAR system are all lagged endogenous variables or even exogenous variables, the problem of simultaneity does not arise and the ordinary least squares method is an appropriate estimation technique.

In standard VARs, the number of time intervals (p parameter) is the same for all the endogenous variables included in the system. The VAR's p order was initially determined using the Akaike Information Criterion (AIC). However, the number of time intervals established this way did not give us error terms exempt of autocorrelation, a desirable property for ensuring the accuracy of the inference results.[38] The number of time intervals (p value) was increased until we obtained error terms with behaviour acceptable for all the models. In practice, a VAR process of the 4th order made it possible to obtain non autocorrelated residuals for all the equations. We therefore retained the value p = 4 for all the VAR models estimated.

We also performed Granger causality tests to verify to what extent the different blocks of explanatory variables (one block containing all the time intervals for a given variable) help directly forecast the rate of quarterly variation in new housing prices. The time intervals in housing starts, real interest rates, inflation and new housing prices prove useful in directly forecasting new housing prices. The time intervals in the *Employment* variable are marginally useful (confidence level of 11%)[39], while we can reject the hypothesis that time intervals in real construction costs are useful in directly predicting housing prices.[40] On the other hand, construction costs help to predict housing starts and inflation, variables that help to predict housing costs.

4.5 Analysis tools

To study housing price determinants, we will use the analysis tools suggested by literature on the vector autoregression technique, i.e. the "*impulse response function*" and "*variance decomposition*." In a VAR model, the origin of the fluctuations in the endogenous variables is linked to disturbances in the error terms. These terms, however, are the residuals of reduced forms and have no immediate structural interpretation. Each error term corresponds to a commingling of structural shocks because of the contemporary correlations existing between them. Hence, an inflationary shock can immediately affect several of the system's variables and, consequently, be linked to several equations' error term. To allocate the dynamic effects to the right determinants, it is necessary, using identification assumptions, to appropriately distribute the proportions of the estimated residuals that are common (that is, to decompose the reduced form residuals) to obtain the structural residuals specific to each determinant. In a VAR system, these structural shocks are seen as the determinants of the variations in the endogenous variables present.[41]

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38 For verifying the presence of autocorrelation, we made use of the LM multivariate error autocorrelation test (for the 1st to the 5th orders).

39 The 11% confidence level (*P value*) must be interpreted as follows: what level of risk do we accept in order not to dismiss the assumption of joint nullity of the coefficients associated with the *Employment* variable. In this case, the statistical confidence level calculated is higher than the critical 5% standard, indicating a relatively high level of risk. However, from a theoretical point of view, the idea that employment is a significant direct determinant of housing prices is widely held.

40 This finding corroborates a conclusion that emerges from the literature that it is empirically difficult to properly zero in on the role of construction costs in the dynamic determination of housing prices.

41 Here, the concept of "*structural*" shocks corresponds to shocks so that it is possible to provide a structural explanation (cause and effect, as in structural macroeconometric models) for impulse responses in the VAR. The term "*structural*" is not to be understood as being the contrary of "*conjunctural*".

Impulse response functions show us how, in dynamic terms, an endogenous VAR model variable (real housing prices, for example) reacts when a previously identified structural shock disturbs the system. For its part, variance decomposition is an analysis tool for decomposing predicted variations in the VAR model's endogenous variables based on the contribution by the different structural shocks identified. In other words, variance decomposition provides us with an empirical evaluation of the different determinants' significance in fluctuations of the endogenous variables.

The results obtained will depend on the identification assumptions retained. They can vary substantially, hence the importance of paying particular attention to the establishment of the identification assumptions. There are no statistical tests to verify the quality of our identification assumptions. The objective is to find, to the best of our knowledge, real structural shocks based on the reduced form residuals.

4.6 Identification assumptions

A standard technique for identifying structural shocks is to use residual triangulation (Choleski orthogonal factorization). This requires the ranking of the endogenous variables present in the VAR model. The ranking principle is to put in first place the variables that exert a contemporary influence on the other variables, but that are not immediately influenced by the variables that follow. Economic theory and certain widely recognized empirical regularities guided our ranking choice.

For the VAR models with six endogenous variables, we retained the following order: (1) inflation, (2) real interest rate, (3) employment or real retail sales, (4) real construction costs, (5) housing starts and (6) real housing prices. For the VAR variants with seven endogenous variables, the variables are ranked as follows: (1) inflation, (2) real interest rate, (3) employment, (4) real construction costs, (5) real land costs or the TSX stock exchange index (real), (6) housing starts, and finally (7) real housing prices.[42] These identification assumptions complete the specification of our VAR models.[43]

4.7 How to interpret shocks and their impulse responses

The shocks identified in this manner correspond to unexpected disturbances (not predicted by the model). They are linked exclusively to one or another of the endogenous variables in the estimated VAR model, that is, to the different real housing price determinants.

The real interest rate shock can be interpreted as a monetary policy shock. The employment shock is a demand shock other than monetary; it may be linked, for example, to the budget policy or to the American economic situation. Shock to CPI growth is an inflationary shock (linked, for example, to fluctuations in the Canadian dollar or to a rise in relative energy costs). The shock associated with construction costs reflects unanticipated variations in the costs of labour or

[42] The position of the TSX stock market index has little significance as long as it comes after real interest rate.
[43] We verified the implication of retaining different sequences. Some led to implausible impulse responses, suggesting that the structural shocks had been improperly identified. The others routinely gave results that were qualitatively similar to those implied by the retained sequence.

materials. Shocks in housing starts may reflect, for example, public policy that encourages residential construction or makes land available for residential development. Lastly, shocks related to real housing price will be an expression of exogenous influences or influences by factors that were not considered in the VAR system. In the reference model's variants, land cost shocks and stock market shocks will be added. There, too, these shocks are to be interpreted as surprises, unexpected variations. Moreover, the literature on VAR models uses the term "**innovations**" to designate these shocks. This expresses the meaning of the concept quite well.

A VAR model is a type of dynamic general equilibrium model. In this context, impulse responses to different shocks are not to be interpreted as the direct effect of a variation in one determinant on the variation in real housing prices. The estimated reaction takes into account both the direct effect and the set of indirect effects linked to the different types of dynamic feedback between the variables present in the VAR. They are, so to speak, the equivalent of the multiplier effects obtained in structural macroeconometric models.

5. THE DATA

For the purposes of the project, we built a database of quarterly statistics covering the period from 1972Q1 to 2002Q4. They relate to Canada as an aggregate, as well as to the 10 largest metropolitan areas, namely: *Halifax, Québec, Montréal, Ottawa, Toronto, Hamilton, Winnipeg, Calgary, Edmonton* and *Vancouver*. The variables of interest were identified in the previous section. Thus, the statistical series relate to:

- New Housing Price Indexes
- Housing Starts (residential total)
- Employment (as a number)
- Retail Sales
- Residential Building Construction Price Indexes
- New Housing Price Indexes (land only)
- Consumer Price Indexes
- Yield Rate on 90-day Treasury Bills (Canada)
- Toronto Stock Exchange's TSX (TSE300) Index (Canada).

The pitfalls were many. Most of the series contained historical breaks, which had to be linked with the help of appropriate techniques. Seasonally adjusted data was not always available. Moreover, access to certain series for periods at the beginning of our sample was complicated.

The statistics on housing starts were supplied by CMHC. The other series comes from Statistics Canada, either from Canadian Socio-Economic Information Management (CANSIM) II, CANSIM I, or hard-copy publications. Appendix A describes the statistical series used, its origin and, where necessary, the linkage method employed.

The statistical data on metropolitan areas do not have the same reliability as the national data. For most of the series that interest us, Statistics Canada uses a sample survey methodology to obtain the necessary information. Series for the CMAs are based on smaller samples than the national series. The result of this is larger standard errors in sampling and series containing more erratic fluctuations. A corollary to this phenomenon: The statistics for smaller urban centres are less reliable than for major urban centres.[44] Lastly, the older statistics or series are generally less reliable than recent statistics or series; the samples used were routinely smaller and the methods less sophisticated. These are facts, but they certainly have effects on the solidity of the results that will be obtained. This must be taken into consideration in assessing the empirical findings.

6. EMPIRICAL RESULTS AT THE NATIONAL LEVEL

We present hereunder the main empirical findings concerning Canada as a whole. As is customary, the estimated coefficients are not reported since these coefficients have no structural interpretation and since the objective of the VAR analysis is to determine the dynamic interrelations between the variables and not the value of the parameters estimated.

At the national level, the estimation covers the period from 1972Q1 to 2003Q3. As suggested by Sims (1986), the endogenous variables' dynamic reactions to the various shocks are best described by a graphic depiction. Since this study seeks to explain the evolution of housing prices, we will present the results that directly relate to this variable. **Figure 2** and **Table 1** present the cumulative dynamic reaction of real housing prices to six shocks (innovations) of 1% (or one percentage point) associated with the system's six endogenous variables (the six determinants).[45, 46] The six shocks are: a real interest rate shock or monetary shock; an employment shock or a non-monetary demand shock; an inflation shock; a real construction-costs shock; a housing-starts shock, and a real-housing-price shock.

Afterward, we will present the variance decomposition results, or the proportion of historical real housing price variations that are attributed to the various shocks. Finally, we will look at certain complementary findings drawn from variants of the VAR reference model.

6.1 How do housing prices react to shocks in their primary determinants?

Table 1 describes the cumulative reaction of housing price growth in Canada as a result of 1% shocks in the various determinants considered in the model. Figure 2 illustrates these impulse responses. Generally speaking, the estimated effects are plausible and in keeping with expectations.[47] However, the uncertainty that surrounds these estimations is fairly substantial and

[44] Usually, Statistics Canada does not calculate the confidence intervals of the statistical series it produces because of their longitudinal nature. We must therefore make do with the short quality statements Statistics Canada issues about its various surveys. Specific to the reliability of CMA series, the reader may consult the article "Quelques observations sur les régions infra-provinciales et les estimations des moyennes mobiles de 3 mois" published in *La Population Active [Labour survey]*, Catalogue 71-001, January 1991, page C-2.

[45] In our presentation, impulse responses will always be expressed cumulatively. Considering that the variable "*Real New Housing Prices*" is modelled as a logarithm, a shock's estimated ripple effects will be interpreted as a percentage difference (rise or decline) in real housing prices in relation to the shock-less scenario a given number of quarters after the shock.

[46] The shocks were standardized to 1% to facilitate their interpretation. In the literature, they refer most often to a shock equivalent to a standard deviation of the structural residuals.

[47] Generally, the confidence intervals associated with these impulse responses are wide and reflect the small number

reflects the limited number of observations in relation to the high number of coefficients to be estimated in the VAR. This uncertainty particularly impacts the effects of employment and construction-cost shocks.

Figure 2
Cumulative Real Housing Price Impulse Responses (CANADA – Reference Model)

To a 1-percentage-point inflation shock
Quarter

To a 1-percentage-point employment shock
Quarter

To a 1% housing-starts shock
Quarter

To a 1-percentage-point real-interest-rate shock
Quarter

To a 1% construction-costs shock
Quarter

To a 1% real housing price shock
Quarter

of observations available in relation to the fairly high number of coefficients to be estimated.

Figure 2

Réponses dynamiques cumulées des prix réels des logements
(CANADA; modèle de référence)

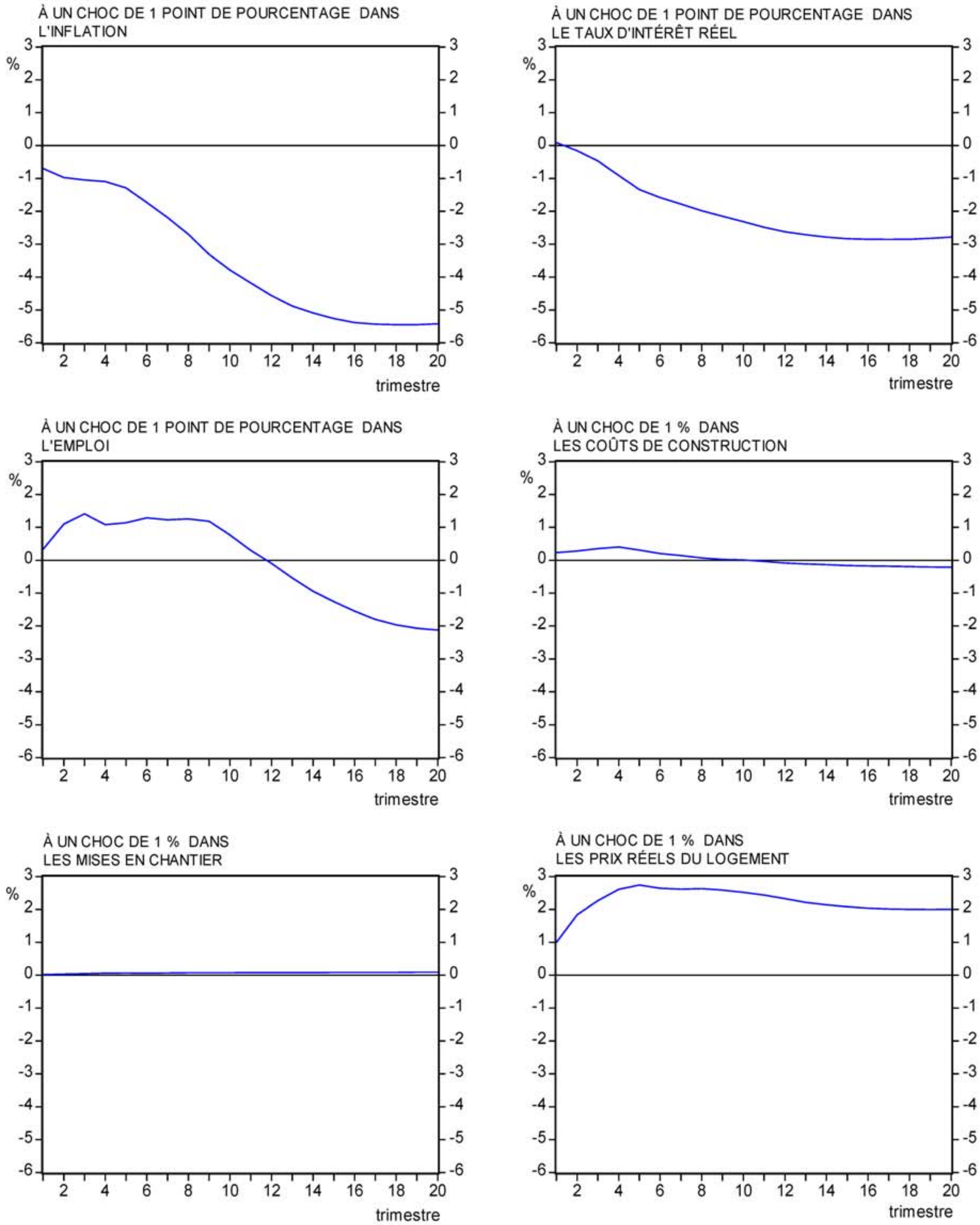

Table 1 - Canada

CUMULATIVE IMPULSE RESPONSES OF GROWTH IN NEW HOUSING PRICES TO SHOCKS OF 1% OR ONE PERCENTAGE POINT (With the reference model) in						
Horizon (Quarter)	**CPI**	**Y90**	**EMPLOYMENT**	**CC**	**HS**	**NHPI**
1	-0.70	0.09	0.34	0.24	0.02	1.00
2	-0.97	-0.16	1.10	0.28	0.04	1.84
3	-1.05	-0.47	1.41	0.36	0.05	2.27
4	-1.09	-0.91	1.09	0.40	0.06	2.61
5	-1.29	-1.34	1.14	0.31	0.07	2.74
6	-1.73	-1.58	1.29	0.21	0.06	2.64
7	-2.19	-1.78	1.23	0.14	0.07	2.62
8	-2.70	-1.98	1.26	0.07	0.07	2.64
9	-3.31	-2.15	1.18	0.03	0.07	2.59
10	-3.79	-2.31	0.77	0.01	0.07	2.51
11	-4.18	-2.49	0.31	-0.03	0.08	2.44
12	-4.57	-2.62	-0.09	-0.08	0.08	2.33
13	-4.88	-2.72	-0.54	-0.11	0.08	2.21
14	-5.09	-2.79	-0.95	-0.13	0.08	2.14
15	-5.26	-2.83	-1.26	-0.16	0.08	2.09
16	-5.38	-2.85	-1.55	-0.17	0.08	2.04
17	-5.43	-2.86	-1.8	-0.18	0.08	2.01
18	-5.45	-2.85	-1.97	-0.19	0.09	2.00
19	-5.45	-2.82	-2.07	-0.20	0.09	1.99
20	-5.42	-2.79	-2.12	-0.21	0.09	2.00

A non-accommodating policy raising real interest rates will have a substantial negative effect on real housing prices. However, we see significant time intervals, which is consistent with empirical literature on the effects of monetary policy. In the first three quarters, the effects are rather limited. The largest part of the impact is felt between the end of the first year and the end of the third year following the shock. Table 1 shows that a one-percentage point rise in real interest rates reduces real housing prices by about 1% after four quarters and by 2% after eight quarters. At the end of five years, the cumulated effect is a decline of 2.8% in real housing prices. We recall that these effects not only account for the direct impacts, but for all the system's dynamic feedback.

As a comparison, the effects of a positive monetary shock on housing starts (Figure 3; Table 2) are faster and larger. The impact is noticeable as early as the second quarter. It is maximal after five quarters and then corresponds to a combined 6.5% decline in housing starts. The effect persists even after five years.[48] Clearly, housing prices and residential construction activity exhibit remarkable sensitivity to monetary shocks.

As expected, an **employment shock** (or a global non-monetary demand shock) stimulates real housing prices as well as housing starts. However, the estimated effects are more uncertain and much less persistent than the effects of monetary shocks. A one percent shock produces a rise in housing prices of roughly 1.5% after three quarters and 1.3% after eight quarters (Figure 2 and Table 1). After three years, the influence peters out and become negative. The response of housing starts to this same shock is massive in the short term (11% after two quarters), more erratic and them becomes very weak after three years (see Figure 3 and Table 2).[49]

An **inflationary shock** has a gradual downward effect on real housing prices (Figure 2 and Table 1). The influence is fairly weak during the first year, but becomes very substantial over time. Maximum impact (-5.4%) is reached after 4.5 years. By the end of four quarters, a 1% inflationary shock reduces the real housing price by about 1%. This effect is 2.7% at the end of eight quarters and reaches roughly 5% after four years. This response can be linked to the recessionary effects of inflationary shocks (including the reaction of the monetary authorities) and to the fact that the nominal interest rate, not solely the real interest rate, is important for households who are forced to borrow. Although this is not incompatible with these findings, there is no evidence that an inflationary context stimulates the Canadian real estate market on the basis of arguments by Summers [1981] and Poterba [1991], arguments related to taxation.[50]

An inflationary shock also interferes with residential construction, but more weakly (Figure 3 and Table 2). In the short term, the effect seems very volatile. In the longer term, an inflationary shock reduces housing construction by about 1%.

Real housing prices respond positively to a **real construction costs shock**. These effects are very weak (less than ½ of 1%) and gradually disappear after one year. They are almost nil at the end of three years. This dynamic reaction is consistent with the assumption that builders have a hard time passing on real cost hikes to homebuyers. But it may be that the VAR model has difficulty measuring the role played by this supply factor.[51]

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[48] The impact on construction costs is also negative, but much more sustained. Actually, construction costs are minimally influenced by the system's other variables, except perhaps inflation (negative influence).

[49] It may be that the VAR model succeeds poorly in accounting for the effects of employment growth or, more globally, of economic activity on housing prices and housing starts. One assumption is that employment shocks may be improperly identified; this is possible, but the results obtained are fairly sound in relation to the identification assumptions retained.

[50] These direct positive inflation effects on real estate activity may be dominated by macroeconomic effects. There are, however, good reasons to believe that these effects stemming from taxation are less important in Canada than in the United States because of the non-deductibility of mortgage interest charges for owner-occupants.

[51] In the literature, despite their efforts, researchers had a lot of difficulty clearly identifying the role and dynamics of supply factors. This is particularly true when an attempt is made to simultaneously consider supply and demand factors [Meen [2001)]. We verified whether the fact of simultaneously or separately including a "labour cost" or another "materials cost" variable in the model modified the responses obtained. The results are entirely similar to those obtained with the reference model.

Table 2 - Canada

CUMULATIVE IMPULSE RESPONSES OF GROWTH IN HOUSING STARTS TO SHOCKS OF 1% OR ONE PERCENTAGE POINT (With the reference model) in						
Horizon (Quarter)	**CPI**	**Y90**	**EMPLOYMENT**	**CC**	**HS**	**NHPI**
1	-1.07	-1.81	11.31	1.78	1.00	0.00
2	-3.75	-4.14	11.01	1.43	0.77	5.54
3	1.66	-3.96	5.51	2.92	0.6	4.11
4	2.39	-5.11	-0.96	1.46	0.55	0.33
5	0.64	-6.46	-2.56	-1.71	0.59	-0.43
6	-2.33	-5.59	1.63	-1.37	0.60	-1.36
7	-1.23	-4.19	2.56	-0.77	0.57	-0.94
8	-0.88	-4.44	2.14	-0.26	0.61	0.36
9	-1.76	-5.03	2.72	-0.32	0.62	0.63
10	-1.96	-5.13	0.68	-0.32	0.60	0.18
11	-0.73	-5.25	-0.98	-0.23	0.61	0.03
12	-0.70	-5.29	-0.34	-0.47	0.60	-0.13
13	-1.45	-5.13	0.36	-0.58	0.60	-0.26
14	-1.19	-5.02	0.20	-0.46	0.62	-0.10
15	-0.82	-4.99	0.39	-0.42	0.62	0.17
16	-0.9	-4.98	0.59	-0.4	0.61	0.18
17	-0.92	-5.00	0.33	-0.39	0.61	0.12
18	-0.78	-5.02	0.28	-0.44	0.61	0.14
19	-0.77	-4.97	0.57	-0.46	0.61	0.13
20	-0.81	-4.92	0.72	-0.43	0.61	0.14

Real housing prices react positively, but on average very weakly, to a **shock in housing starts** (Figure 2 and Table 1). An unanticipated shock in housing starts (here we think of a new government policy) stimulates real housing prices. This impulse response is compatible with the idea that residential construction has little success in the short and medium term re-establishing housing supply and demand equilibrium. We note, however, that this low sensitivity is offset in part by the large size of the shocks associated with housing starts.[52]

Figure 3
Cumulative Housing Starts Impulse Responses (CANADA – Reference Model)

[52] In the face of this 1% "real" shock, effects on housing starts are sustained. After five years, housing starts are still 0.6% higher than they were before the shock.

To a 1-percentage-point inflation shock

Quarter

To a 1-percentage-point employment shock

Quarter

To a 1% housing-starts shock

Quarter

To a 1-percentage-point real-interest-rate shock

Quarter

To a 1% construction-cost shock

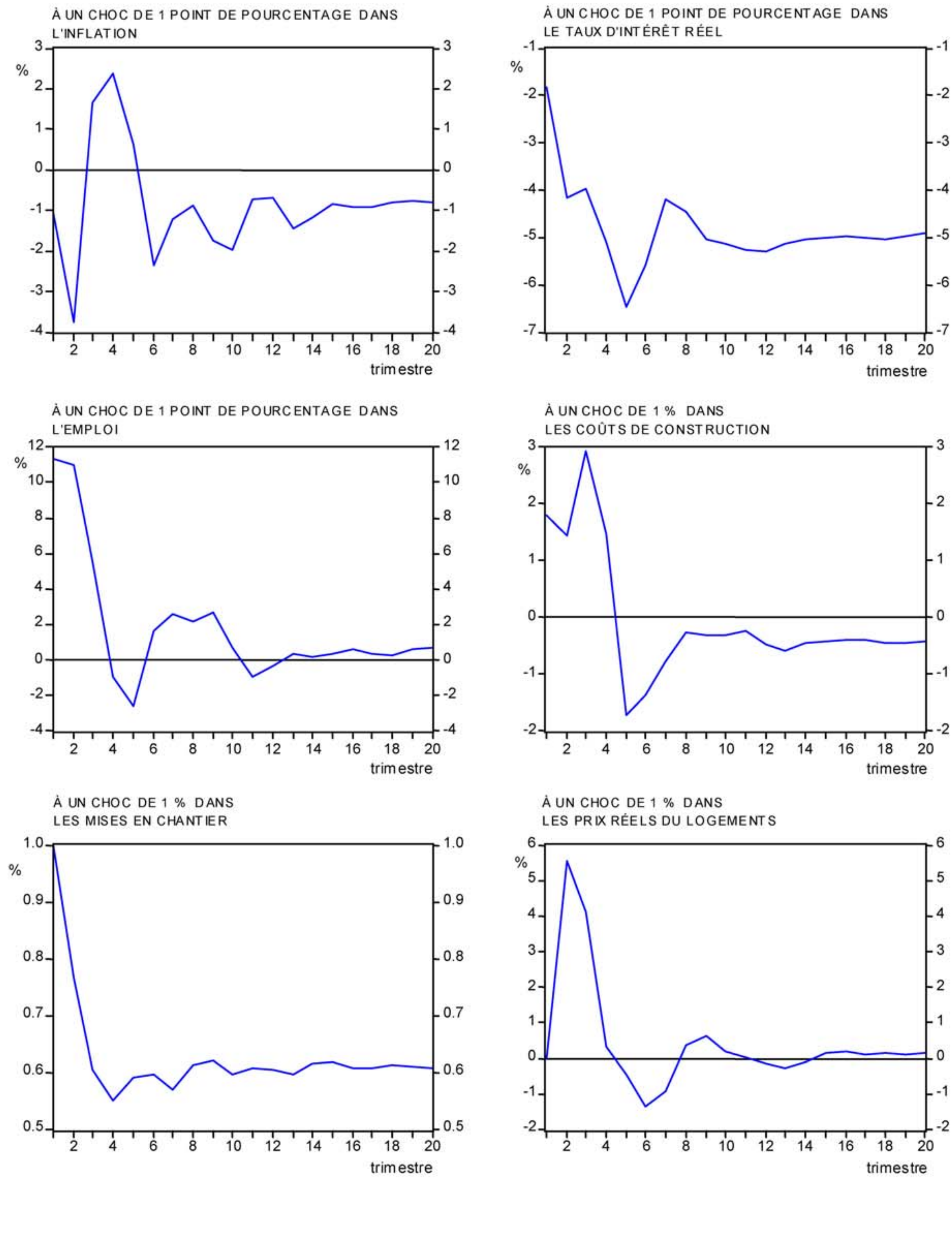
Quarter

To a 1% real-housing-price shock

Quarter

Figure 3

Réponses dynamiques cumulées des mises en chantier (CANADA; modèle de référence)



Lastly, a **real housing price shock** raises real housing prices very substantially, for a prolonged period (Figure 2 and Table 1). An unanticipated 1% shock implies a combined 2.6% increase in real housing prices between the fourth and eighth quarters after the shock. After five years, real housing prices are still 2% higher in relation to pre-shock prices. This impulse response indicates not only a great deal of persistence in housing price fluctuations, but probably an overreaction compatible with the existence of real estate bubbles. This same shock is a strong residential construction stimulus in the very short term. In the longer term, however, this influence is minimal.

6.2 Significance of the various determinants in historical housing price variations

Housing price impulse responses in the face of different shocks in the determinants provide an incomplete picture. The role a factor plays in explaining historical fluctuations in housing prices (or housing starts) depends not only on impulse response functions, but also on shock size. Figure 4 summarizes the various shocks' estimated contribution in the explanation of historical variations in real housing prices for a five-year horizon.[53] These estimations are means. It is evident that the significance of the role played by a determinant can vary with the periods considered.

First observation, fluctuations in real housing prices are for the most part produced by its own shocks (43%). There may be several explanations for this finding. It is compatible with the presence of a real property wealth effect and with shocks associated with lands costs. But this suggests above all that the economic factors used in the VAR model explain only a portion of the quarterly variations in housing prices.[54] As we mentioned earlier, this finding is consistent with the idea that basic economic factors alone cannot explain the fluctuations in housing prices (and housing starts) and that the real estate market can be subject to speculative bubbles and overshooting.

Among other shocks, monetary shocks (on the real interest rate) prove the most significant, with a 22% contribution. Employment, which, in the model, captures the effects of changes in population, household income and, more globally, non-monetary demand shocks, makes an 11.4% contribution that may seem low in relation to our *a priori* assumptions.[55] Inflation seems to play a major role in real housing price fluctuations, more important even than the role of employment. This contribution grows with the forecast horizon to reach 15.5% at the end of five years. This finding corroborates that of Tsatsaronis and Zhu (2004), who concluded in an international study that inflation has a very important role as a housing price determinant. Innovations in housing starts and construction costs respectively account for approximately 5% and 2.7% of the variations in real housing prices. These contributions are consistent with the

[53] We could have presented the various shocks' contributions for different horizons. Practically speaking, this provides very little supplementary information.
[54] Sutton (2002) had obtained a similar result for Canada, but not for other countries. Obviously, the fact that the model attempts to explain the quarterly variation in housing prices makes this series very volatile and hard to predict.
[55] Some American studies concluded that employment plays an important role; this is the case in the study by Baffoe-Bonnie [1998] who used VAR modelling. Recently, Tsatsaronis and Zhu (2004), also with a VAR model applied to a panel of 17 countries, reached a conclusion similar to ours, that household income plays a relatively minor role in housing price variations.

empirical literature. Housing prices react fairly weakly to the inflow of new construction because this new housing accounts for only a small fraction of the total housing stock. Another explanation relating to construction costs: they prove to be relatively stable over time. (Glaeser, 2004).

Figure 4

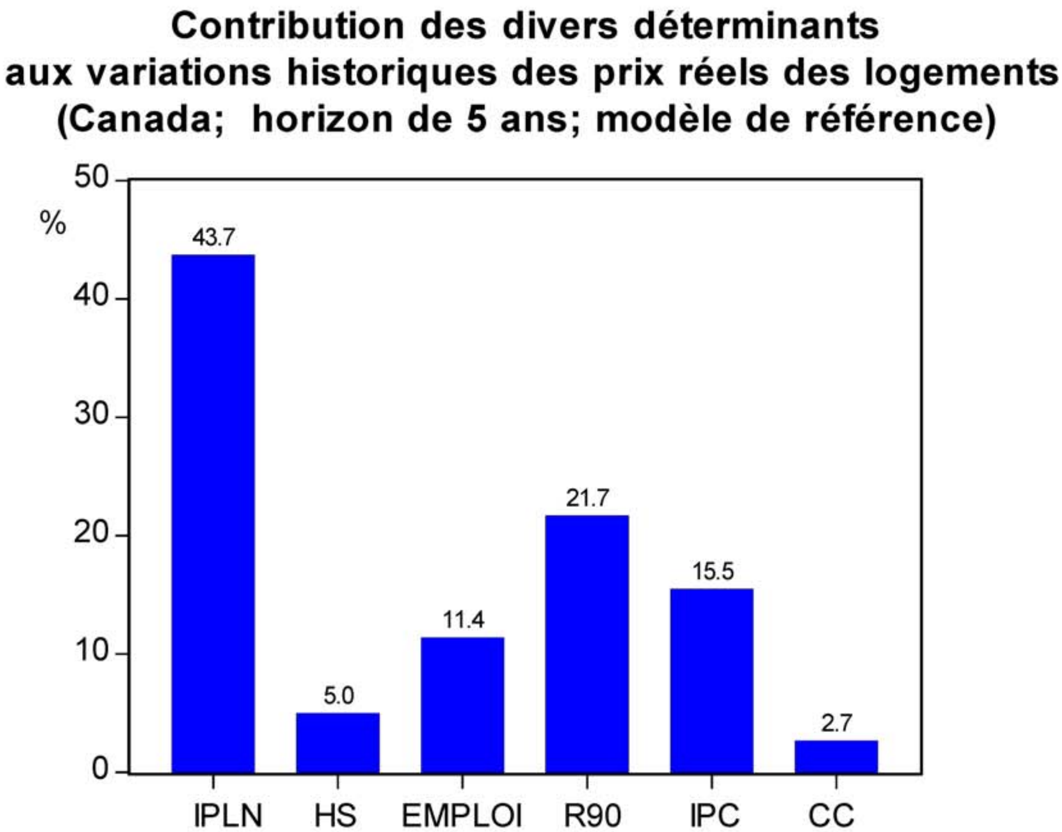


Figure 4
The Contribution of Various Determinants to Historical Real Housing Price Variations (Canada – 5-year Horizon – Reference Model)

NHPI HS EMP'T Y90 CPI CC

6.3 Land cost as a real housing price determinant

We wanted to verify the influence of land costs. To do this, we considered a VAR with seven variables, including land costs as measured by a New Housing Price sub-index. The measurement is far from ideal since it is an exit price (not an entry price) and, since this index is a New Housing Price component, it can pose some econometric problems.[56] Therefore, the results

[56] This is like considering a VAR simultaneously having GDP and consumption as endogenous variables, which is frequently the case in the literature on macroeconomics.

obtained must be interpreted cautiously. The addition of the *real land cost* variable to the reference model substantially increases the model's ability to explain real housing prices. In this way, exogenous shocks on the real housing price see their contribution to fluctuations in real housing prices change from 43% to 25% for the five-year horizon. Exogenous shocks on land prices corner 25% of the short- and long-term variation in real housing prices. This is what is revealed in Figure 5, which presents the contributions of the determinants in this VAR model integrating land costs as an endogenous variable. This is a substantial contribution that is not entirely reliable for the reasons mentioned earlier, but which is not without meaning. Land prices proved somewhat more volatile than house prices before 1990, and probably less predictable.[57] It would be interesting to delve a little deeper into this question. The contribution of other determinants changes a bit in this expanded model; in particular, inflation becomes as important a determinant of real housing price variations as real interest rates (19%).

Figure 5

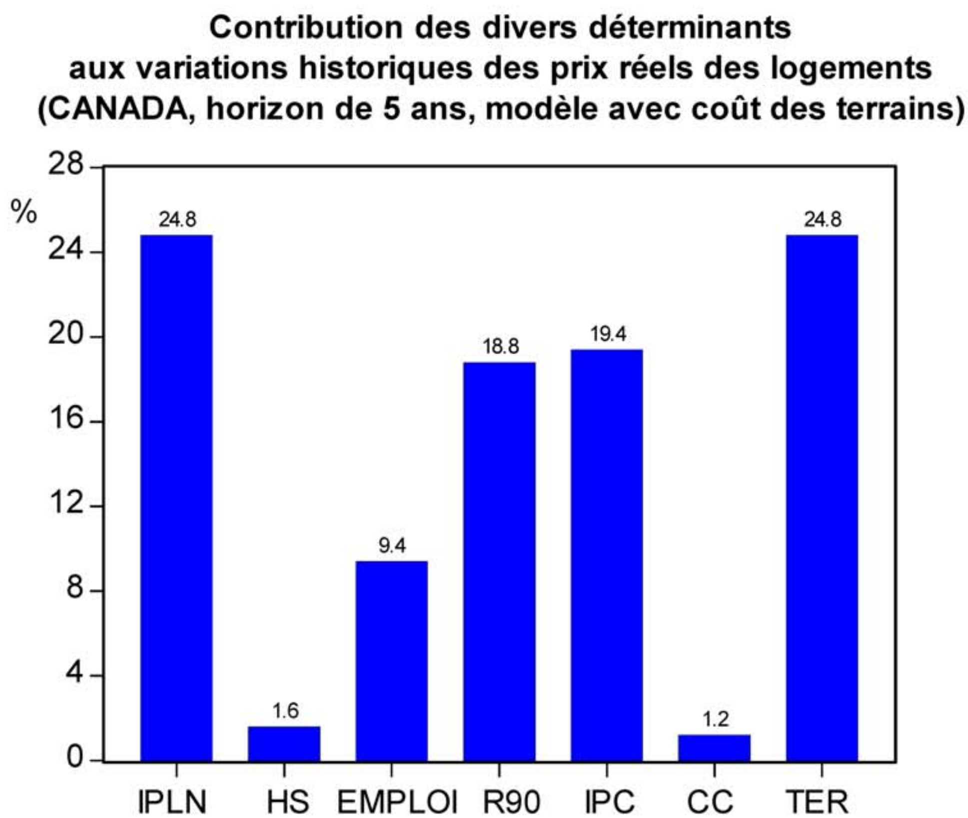


Figure 5

[57] In fact, the standard deviation of the shocks associated with land costs, as estimated by the model, is close to double that of the shocks associated with housing prices, i.e. 0.0094 versus 0.0050.

The Contribution of Various Determinants to Historical Real Housing Price Variations (Canada – 5-Year Horizon – Model with Land Costs)

NHPI HS EMP'T Y90 CPI CC LC

6.4 The stock market's effect on real housing prices

We wanted to verify the significance of stock market wealth as a determinant of real housing prices by integrating real stock market prices (Toronto Stock Exchange TSX deflated by the Consumer Price Index) into the reference VAR.[58] Figure 6 shows the variance decomposition results with this enhanced VAR.

Figure 6

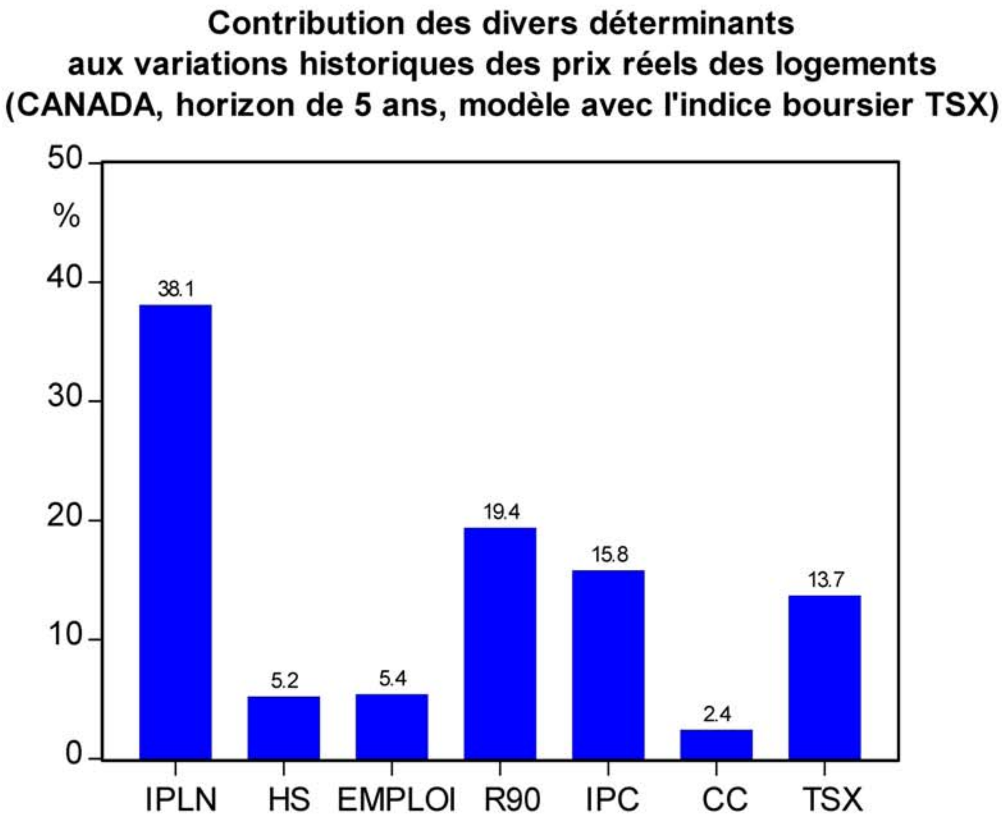


Figure 6
The Contribution of Various Determinants to Historical Real Housing Price Variations (Canada – 5-Year Horizon – Model with TSX Stock Exchange Index)

NHPI HS EMP'T Y90 CPI CC LC TSX

[58] The seven-variable VAR is of the 4th order. The identification assumptions scarcely change the results obtained.

These results follow the same direction as those obtained by Sutton (2002) for various countries, including Canada: stock market shocks would be a significant determinant of housing prices (13.7% contribution), more significant even than employment, whose contribution is reduced to 5.4%. Therefore, the stock market boom in the second half of the 1990s would have stimulated growth in housing prices, while the stock market crash that followed would have slowed this growth.

There are good reasons for interpreting these findings with caution. On the one hand, empirical literature on consumption functions suggests a positive but relatively weak stock-market-wealth effect. On the other hand, the inclusion of real stock market prices in the reference VAR substantially reduces the contribution of employment shocks to real housing price fluctuations, a contribution that we deem already too small compared to our expectations. As the TSX is a leading indicator of the situation, it is probable that this variable appropriates part of the *Employment* variable's effects and that these variables' respective structural shocks were poorly identified.

The same comments apply to the impulse response of housing prices to a stock market shock. Figure 7 illustrates this impulse response for a shock corresponding to a standard deviation of the residuals.[59] Housing prices respond positively, substantially and persistently to an exogenous stock market shock. Here again, the response seems too quick to be entirely credible.

Figure 7

[59] Since the real TSX is level in the VAR model, it was not possible to standardize the response functions to make them correspond to a 1% or 10% shock.

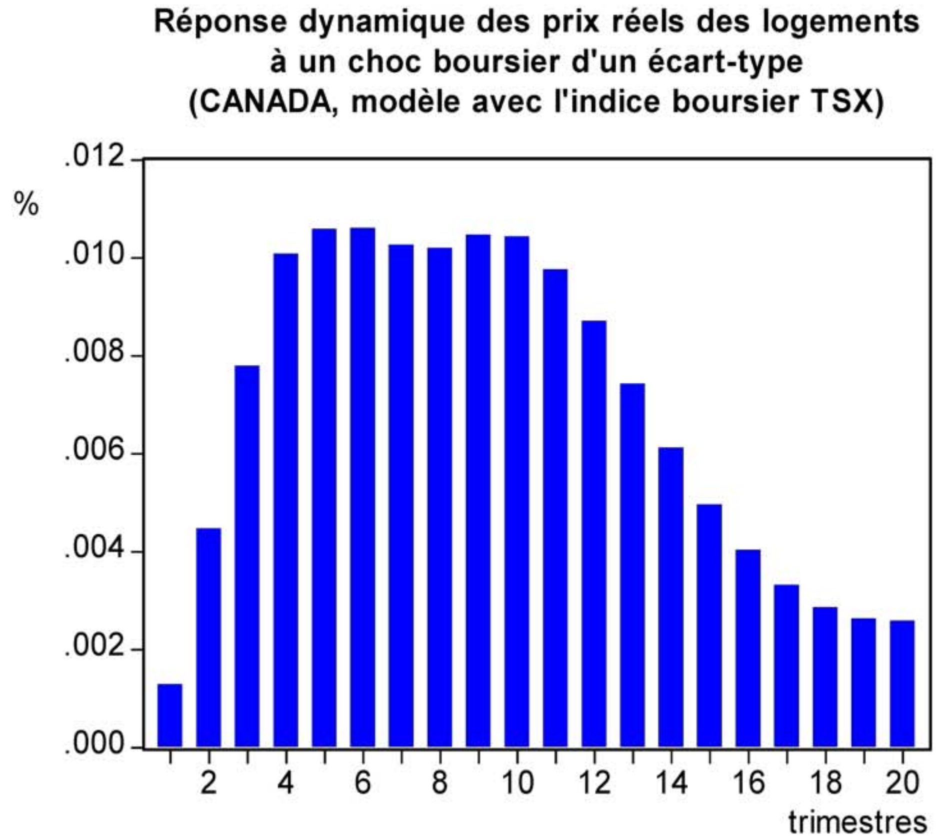


Figure 7

Real Housing Price Impulse Response to a Standard Deviation Stock Market Shock
(Canada – Model with TSX Stock Market Index)
Quarters

All in all, stock market prices are a determinant of real housing prices. This factor will act through a wealth effect. Unfortunately, in a vector autoregression methodology framework, measurements of this effect are quite obviously overestimated because of the statistical properties of stock market indices.

6.5 What do we deduce from these national empirical results?

The VAR reference model gives empirical results at the national level that are most interesting despite the constraints related to sample size. We find that the most important determinants of real housing price variations are monetary shocks (real interest rates), which explain 22% of the historical housing price variations, and inflation, with a 15% contribution in the reference model. Although we are not surprised by the result with respect to interest rate shocks, its major role is more surprising, although not totally unexpected. The literature on the subject advances several arguments supporting this finding. Recently, Tsatsaronis and Zhu (2004) reported a similar finding.

Employment, which in our model also represents population and income, also constitutes a significant, but not dominant determinant. The contribution of employment shocks accounts for

11.4% of historical housing price variations in the preferred version of the VAR model. The other factors studied (except for housing price shocks whose contribution is difficult to interpret), namely housing starts and construction costs, are minor determinants.

In some complementary estimations, we concluded that unexpected variations in land costs likely constitute a very significant housing price determinant (contribution estimated at 25%). Similarly, we obtain the same result as Sutton (2002) that stock market wealth is an important housing price determinant (contribution estimated at 13.7%). However, we are presenting arguments that challenge the accuracy of this assessment.

Concerning the dynamics of the effects associated with the different shocks, we specifically retain the long time intervals entailed in the monetary shocks and the amplified and persistent housing price reaction to its own shocks. The latter finding suggests that the real estate market has a tendency to overreact to shocks and is slow to recover equilibrium. This is entirely compatible with the existence of real estate bubbles. Finally, because of their weak effect, shocks in housing starts (in housing supply) can only act in the relatively long term to cure imbalances occurring in the housing market.

7. RESULTS FOR CENSUS METROPOLITAN AREAS

In the previous section, we presented the principal results of the impulse response analyses and variance decomposition at the national level. These results will be used as yardsticks for our metropolitan area analysis, which is the subject of this section.

We estimated the reference VAR model and its variants for each of the 10 census metropolitan areas (CMAs). We also produced a panel estimation of these models. We recall that in this case, the dynamic structure of the VAR is assumed to be the same for all CMAs. Thus, in this section, we are reporting the findings of 11 sets of results. The presentation will combine the results, which will facilitate comparisons.

We have already mentioned that metropolitan area estimations run into a problem with the quality of statistical data available. At this high level of disaggregation, errors in measuring the variables are exacerbated and statistical series exhibit a very volatile (noisy) character. This prejudices the quality of the estimations, particularly in small samples, which is the case here. In addition, in comparison with national estimations, this estimation period is a bit shorter (1975Q1 to 2003Q3) because of the lack of employment statistics prior to 1975. Consequently, we observe that the estimated responses corresponding to the different shocks are more uncertain and less reliable. This is particularly true for the smaller urban centres. One of the objectives targeted by the panel estimation was to reduce this uncertainty. The objective was reached. The impulse responses are all statistically different from zero, except responses relating to the "*Construction Cost*" variable. In this case, however, the impulse responses are very weak. The panel results constitute a most interesting basis of comparison.

We repeat a warning. The estimated responses and contributions reflect not the direct effects of the determinants on real housing prices, but the set of direct and indirect effects that result from the dynamic feedback in the VAR equation system.

But, before examining the regional VAR models' impulse responses as well as the contribution of various shocks' to historical real housing price fluctuations, let us focus our attention on the regional VAR models' predictive capability.

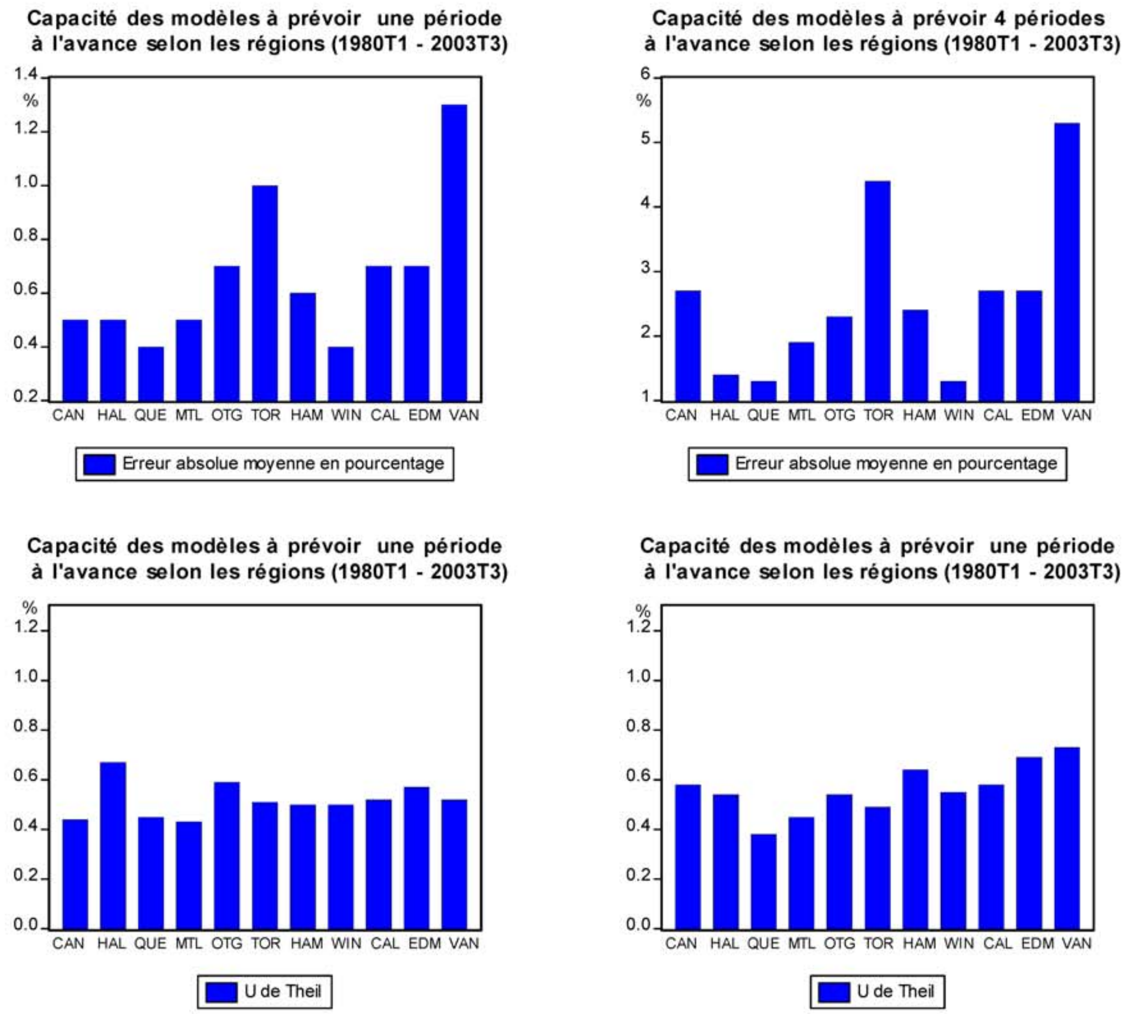
7.1 What is the predictive capability of the regional housing price VAR models?

To what extent do the regional VAR models succeed in retracing the historical evolution of housing prices? This question is not devoid of interest. **Figure 8** presents a comparative assessment of the regional (and national) models' ability to predict one quarter and four quarters ahead according to two aggregated prediction error measurements. These two measurements are the percentage mean absolute error and the Theil inequality coefficient (Theil U). The first measurement can be interpreted directly as a margin of error. The second measurement compares the predictive capability of one model with that of a random walk model (not anticipating any change). A Theil U statistic lower than one means that the model considered predicts better than the random walk model. A U statistic of 0.40, for example, implies a 60% efficiency gain in compared to the random walk model.[60] The prediction period retained extends from 1980Q1 to 2003Q4.[61]

[60] More precisely, the Theil U compares a model's root-mean quadratic error with that of the random walk model.
[61] We removed the 1970s because the data on housing prices was more erratic. It would have been interesting to conduct a prediction exercise outside the estimation period. However, the relatively small size of our sample would make the exercise fairly meaningless.

Figure 8

Capacité prédictive des modèles régionaux des prix des logements



* L'erreur absolue moyenne en pourcentage est une mesure agrégée des erreurs de prévision pouvant être interprétée comme une marge d'erreur.
** Le U de Theil compare la racine de l'erreur quadratique moyenne d'un modèle avec celle d'un modèle de marche aléatoire (pas de changement).
Une statistique U de Theil inférieure à 1 signifie que le modèle considéré prédit mieux que le modèle de marche aléatoire.
Une statistique de 0,40 signifie que le gain en efficience est de 60%.

Figure 8
Predictive Capability of Regional Housing Price Models

Models' capability to predict one period ahead by region (1980Q1-2003Q3) Percentage mean absolute error	Models' capability to predict 4 periods ahead by region (1980Q1-2003Q3) Percentage mean absolute error
Models' capability to predict one period	Models' capability to predict one [*sic*]

ahead by region (1980Q1-2003Q3) Theil U	period ahead by region (1980Q1-2003Q3) Theil U
* Percentage mean absolute error, which can be interpreted as a margin of error, is an aggregate measurement of the prediction errors. ** The Theil U compares a model's root-mean quadratic error to that of a random walk model (no change). A Theil U statistic lower than one means that the model considered predicts better than the random walk model. A statistic of 0.40 means a 60% gain in efficiency.	

The percentage mean absolute errors indicate that the regional models are highly predictive one period in advance. The margins of error are lower than ½ of a percentage point for the VAR models for Canada, Québec City, Winnipeg, Montréal and Halifax. They are a bit higher concerning Ottawa-Gatineau, Calgary and Edmonton, i.e., roughly 0.7%. Toronto and Vancouver respectively show 1.0 and 1.3% prediction margins of error.

As was to be expected, prediction four quarters in advance is less precise. However, prediction error remains very low for the Québec City, Winnipeg and Halifax CMAs, i.e. a little more than 1%. Prediction error is very reasonable with respect to Montréal (1.9%), Ottawa-Gatineau (2.3%), Hamilton (2.4%), as well as Calgary, Edmonton and Canada (all around 2.7%). Once again, the models for Toronto and Vancouver are less accurate at predicting, with 4.4 and 5.2% margins of error.

Broadly speaking, the regions that experienced the greatest real housing price stability in the period from 1980 to 2003 see better prediction in their models. Hence, real housing prices proved very stable in the Québec City, Montréal, Winnipeg and Halifax metropolitan areas. On the other hand, Toronto and Vancouver are the centres that experienced very wide real housing price fluctuations. The most volatile a series are generally more difficult to predict. One explanation for Toronto and Vancouver might be lower land availability for urban development or greater stringency in the environmental regulations with respect to this development. Were this correct, the weaker predictive capability for Toronto and Vancouver would be congruent with the results of Abraham and Hendershott (1996), Malpezzi (1999), Capozza, Hendershott, Mack and Mayer (2002) and Gleaser, Gyourko and Saks (2003) concerning cities on the east and west coasts of the United States.[62]

In Theil U terms, all the models show a far greater predictive capability than the random walk models, for predicting both one quarter in advance and four quarters in advance. The gain in efficiency is fairly similar for all the regional models, sitting between 50 and 60% for predictions one period in advance and between 40 and 60% for predictions four quarters in advance.

All in all, our VAR models have a valuable predictive capability. Prediction errors are generally greater over five years. For this period, predictions tend to underestimate the housing prices observed in almost all the markets. Nevertheless, these errors remain reasonable.

[62] See our literature review.

7.2 Reaction of real housing prices to the various shocks in the determinants

As we have already mentioned, the impulse responses are best presented using graphs (Sims, 1986) that trace the effect of an exogenous shock on one of the VAR's endogenous variables for different horizons. To facilitate interpretation and comparison, we chose to present the impulse responses to a given type of shock for the 10 CMAs and for the panel in the same graph. The response function for Canada is also illustrated in it for comparison purposes. Result tables corresponding to the graphs are appended (Appendix D).

Figure 9 illustrates cumulative real housing price growth rate impulse responses to a one-percentage-point real-interest-rate shock. The responses move in the direction expected for the vast majority of the CMAs: a positive shock in real interest rates lowers real new housing prices. They are relatively similar from one CMA to another. The exceptions are the estimated impulse

Figure 9

Cumulative NHPI Impulse Response to a One-Percentage-Point Y90 Shock
(Canada and CMAs – Reference Model)

Major urban centres

Quarters

Other urban centres

Quarters

Figure 9

Réponse dynamique cumulée de IPLN à un choc de 1 point de pourcentage sur R90 (Canada et RMR; modèle de référence)

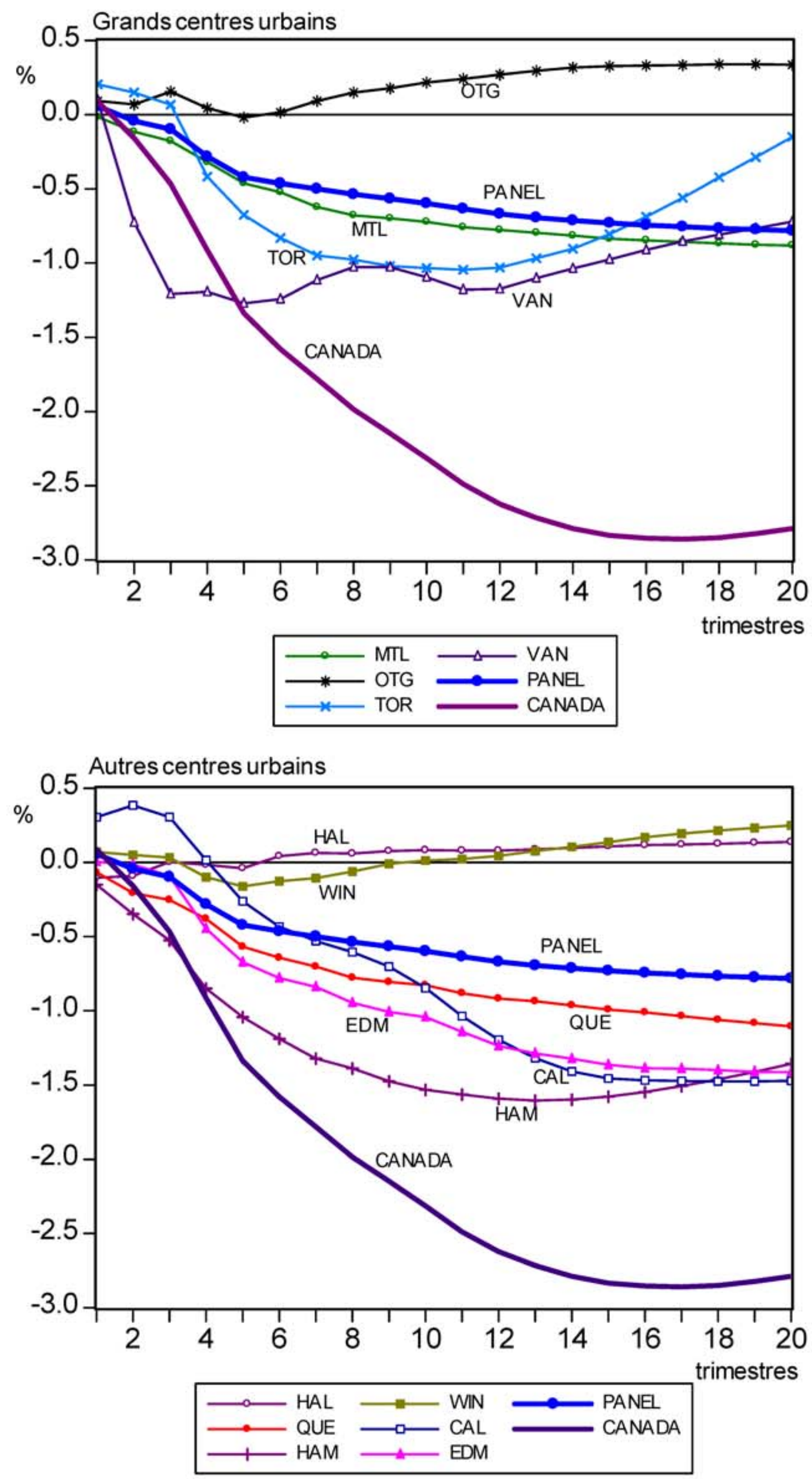


Figure 10

Cumulative HS Impulse Response to a One-Percentage-Point Y90 Shock
(Major Urban Centres – Reference Model)

Major urban centres

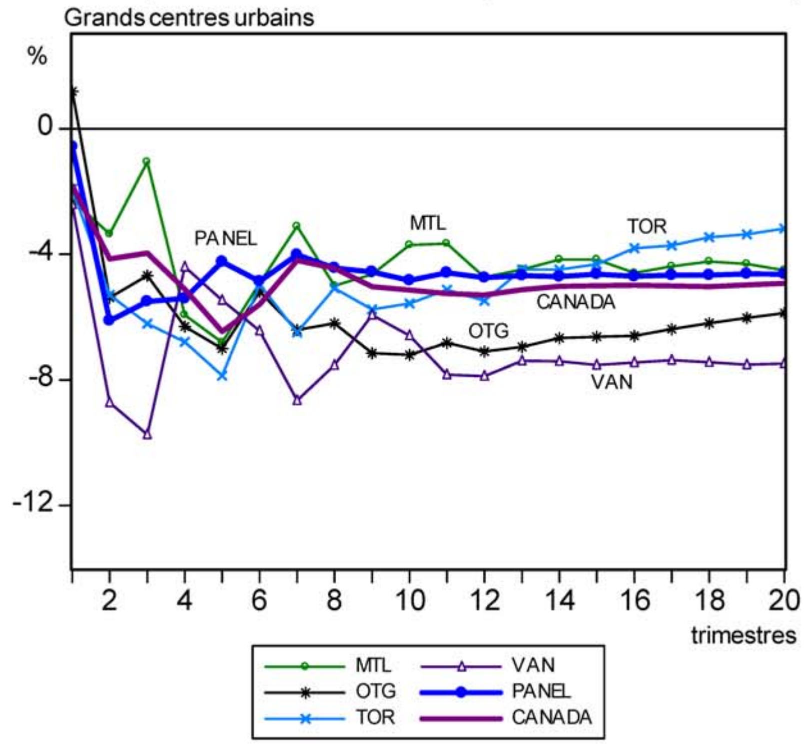
Quarters

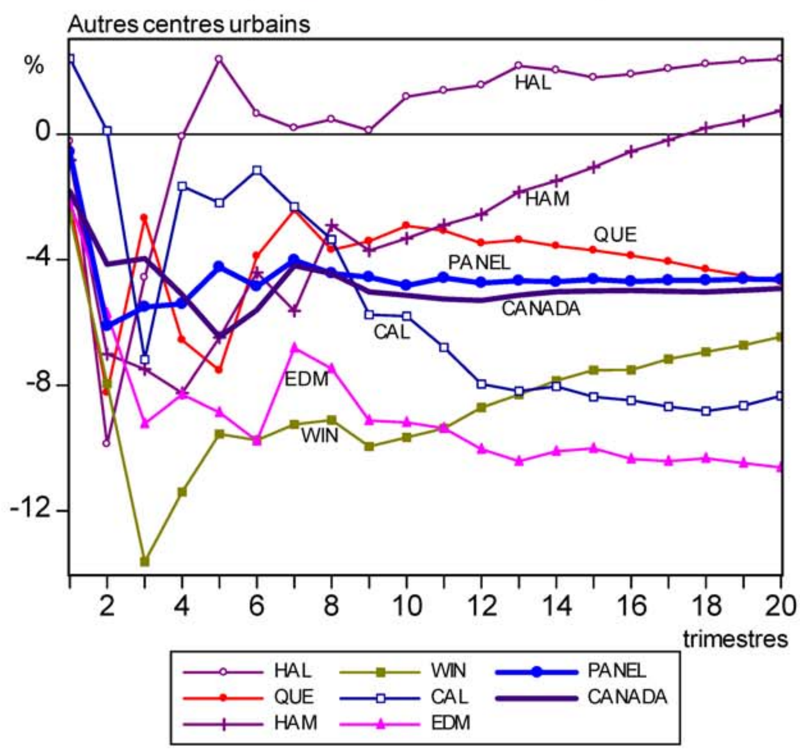
Other urban centres

Quarters

Figure 10

Réponse dynamique cumulée de HS à un choc de 1 point de pourcentage sur R90 (Grands centres urbains; modèle de référence)





responses for Ottawa-Gatineau, Halifax and, to a lesser extent, Winnipeg where the effects do not move in the expected direction, even though they are very weak and not significantly different from zero.[63] As a general rule, it takes time for the effects of monetary shocks to be felt. Before a year, the effects are very weak, after this they increase substantially. However, responses seem to be faster in Vancouver and Hamilton. Another observation: the effects persist for a long time. When compared with what we obtained for Canada, monetary responses are weaker. On the other hand, the responses obtained for the panel are weaker than for the majority of individual CMAs; the decline in housing prices is about ½ of 1% after two years and 1% after three years. However, these various results are consistent with each other and the profile of the impulse response paths are quite similar. Table D.6 in Appendix D presents the detailed impulse responses corresponding to this shock for each of the regions, for the panel and for Canada.

The same monetary shock has greater dynamic effects on housing starts. However, the reaction is much faster than for housing prices, and is felt in the first quarters. According to our panel estimations reflecting a mean reaction for the 10 CMAs studied, a positive real-interest-rate shock equivalent to 100 basis points (one percentage point rise) reduces housing starts by 6.6% after two quarters and by 5.2% in the long term (five years). This response is illustrated in Figure 10 by the **bold** line. The impulse responses are quite similar in the estimations specific to each of the CMAs, and a bit larger for six of the 10 CMAs. Halifax is the only CMA for which the impulse responses are not very plausible.

An employment shock (non-monetary demand shock) leads to a positive real housing price response (see Figure 11). However, these effects may seem relatively weak. Therefore, with respect to the panel estimations, a 1% employment shock leads to a 0.4% rise in real housing prices during the second year. The effects are felt gradually and reach their maximum after eight quarters. If we look at the response paths specific to each of the CMAs, we obtain a fairly similar profile for most of the areas. The Toronto and Vancouver areas exhibit the most sensitivity to an employment shock, although in the latter case, the effects are less persistent. This rather weak sensitivity may be surprising. Some studies that used a single equation model—which is not our case—found that employment was an important direct determinant. However, a recent international study by Tsatsaronis and Zhu (2004) obtained a result equivalent to ours.[64]

Housing starts' responses to the same employment shock exhibit more variation between areas, as can be observed in Figure 12.[65] Estimations specific to the 10 metropolitan areas generally entail a positive response to an employment shock.[66]

[63] These last results do not imply that monetary restriction has a positive effect on real housing prices, but rather that the statistical data, within the framework of the proposed VAR models, are unable to measure this effect with the accuracy required.

[64] Actually, in their study, the variable used is not employment but GDP as a measurement of household income and as cyclical indicator.

[65] The volatility of housing start responses in the short term probably results from the very great variability in the series on housing starts.

[66] With regard to this, the results for the Winnipeg, Edmonton and Ottawa-Gatineau CMAs are exceptions. It is difficult in these cases to explain how an employment shock can slow down residential construction. It is possible that the employment shocks were poorly identified. In this respect, the fact that housing starts are an advanced employment cycle indicator may have caused a problem.

Figure 11

Cumulative NHPI Impulse Response to 1% Employment Shock
(Canada and CMAs – Reference Model)

Major urban centres

Quarters

Other urban centres

Quarters

Figure 11

Réponse dynamique cumulée de IPLN à un choc de 1% sur EMPLOI
(Canada et RMR; modèle de référence)

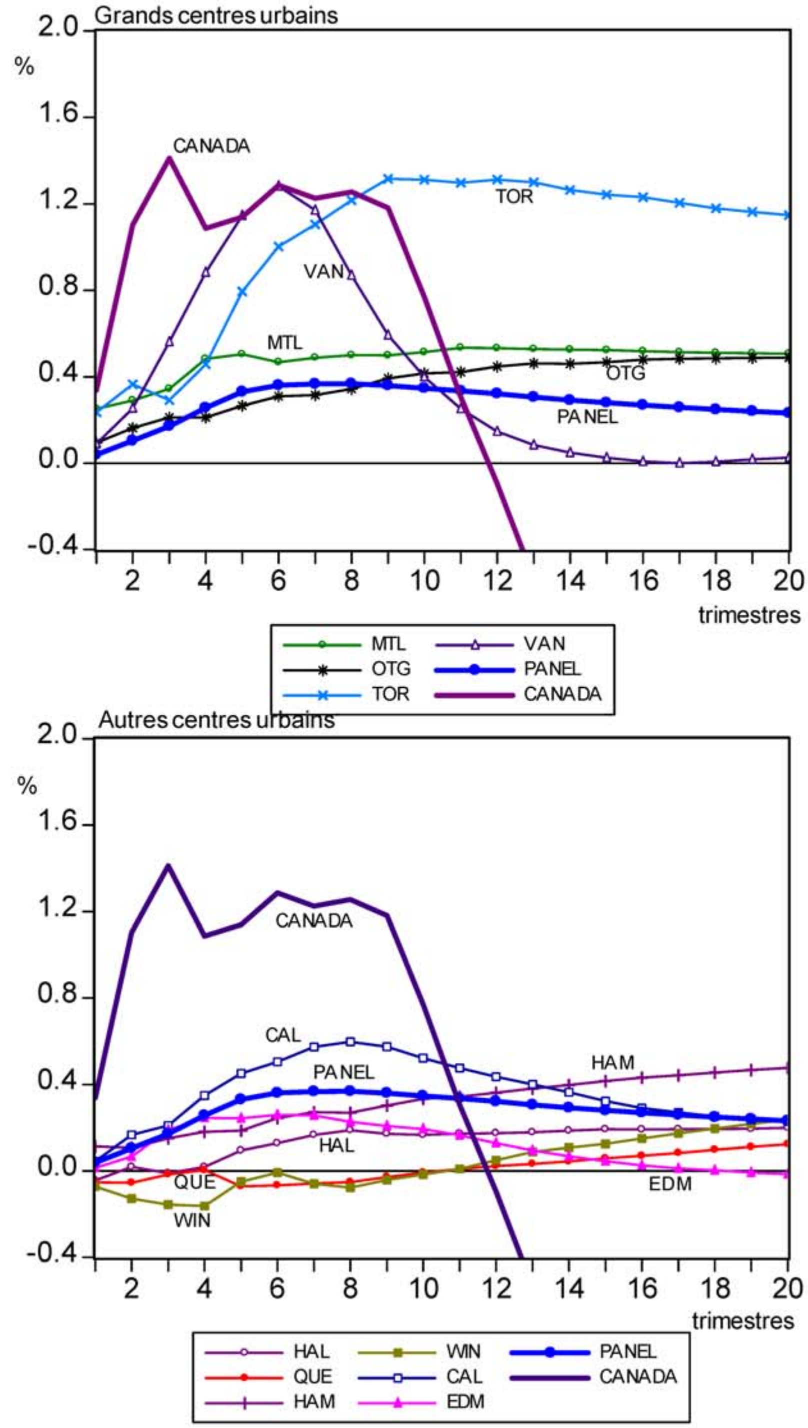


Figure 12

Cumulative HS Impulse Response to 1% Employment Shock
(Major Urban Centres – Reference Model)

Major urban centres

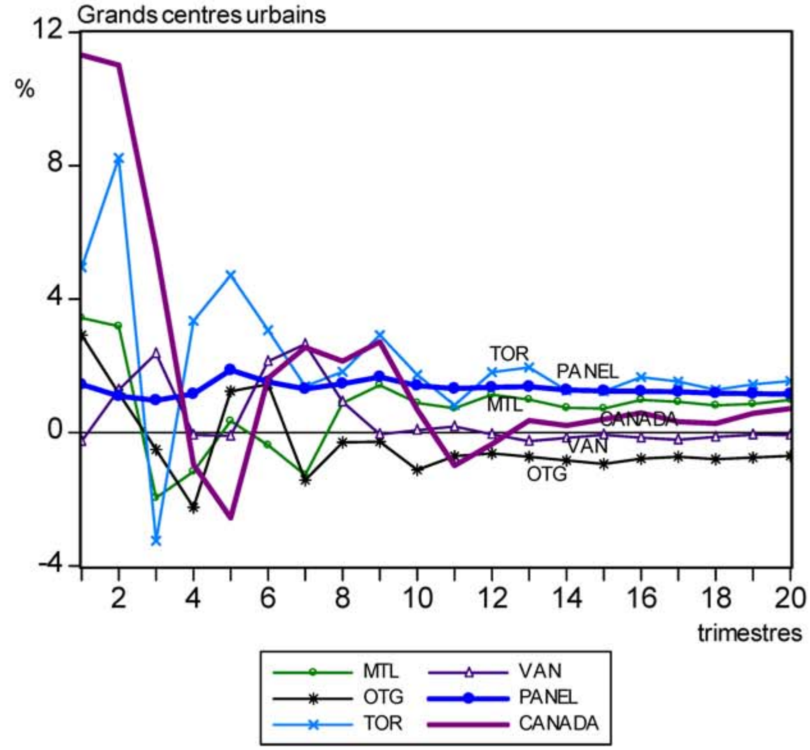
Quarters

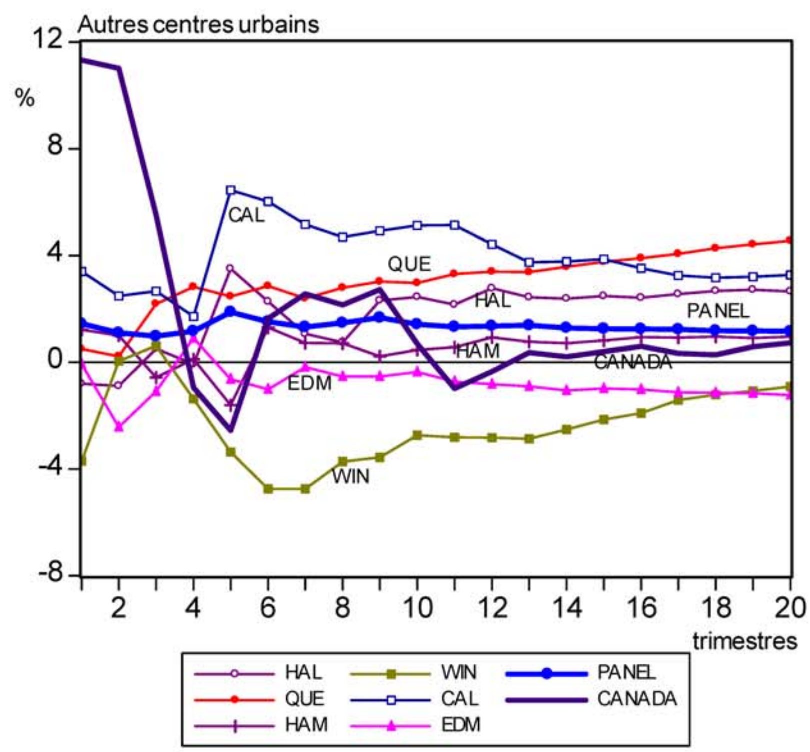
Other urban centres

Quarters

Figure 12

Réponse dynamique cumulée de HS à un choc de 1% sur EMPLOI
(Grands centres urbains; modèle de référence)





This response is stronger for Calgary and Québec City CMAs. The panel estimations suggest a relatively flat impulse response where the maximum compounding effect is attained in the fifth quarter after the shock. A typical 1.6% employment shock stimulates housing starts by roughly 3% after five quarters and 2% in the long term. New housing construction is therefore more sensitive than real housing prices to a non-monetary demand shock.

Figure 13 illustrates real housing prices' strong negative reaction to an inflationary shock. For all CMAs, on the basis of the panel estimations, an unanticipated rise of one percentage point in the inflation rate results in a decline in the order of 0.75% in real prices during the first year following the shock and the compounding effect becomes more pronounced, reaching 3.4% after five years.[67] This effect is substantial, even though it is less than what had been estimated for Canada. Responses vary appreciably by metropolitan area. An inflationary shock's long-term impact seems greater in Calgary, Edmonton, Toronto and Vancouver. For the last two, we note inflation's positive influence in the short term, which is compatible with the theory.

We recall that, from a theoretical perspective, the effect of inflation on real housing prices (and more broadly on housing demand) is vague. Insofar as homebuyers are forced to borrow, the nominal interest rate is important. The rise in mortgage rates balloons mortgage payments and limits housing demand and, because of this, growth in housing prices. In our VAR model, these supplementary nominal interest rate effects (over and above real rates) are taken into account by "*innovation*" in the inflation equation.[68] On the other hand, in a time of high inflation, real estate can be seen as an investment better protected against inflation, which stimulates housing demand and real prices (positive effects). Besides this, the non-neutrality of the taxation system in the face of inflation may foster the demand for housing and raise its price in a period of high inflation. Added to all this is a dynamic dimension: if, for various reasons, nominal housing prices adjust more slowly to an inflationary shock than other prices, we will see a short-term decline in real housing prices. Our findings clearly indicate that an inflationary shock's negative effects dominate easily.[69]

The observation is somewhat different with respect to an inflationary shock's effects on housing starts (Figure 14). The impulse response is generally positive for short horizons and then becomes negative in the longer term.[70] The panel estimations imply that a 1% inflationary shock increases housing starts by 8% after four quarters — this is the maximum positive effect — but reduces them by 5% in the long term (after five years).[71]

---

[67] The mean standard deviation of the structural residuals for all CMAs is 0.57%, which gives an idea of the size of the inflationary shocks that disturb the VAR system.

[68] Another argument holds that high inflation is linked to a more uncertain environment, which can discourage real estate investment considering the relatively low liquidity of a home purchase.

[69] However, the effects' ambiguity may explain the results obtained for Vancouver and Toronto, which reveal an impulse response to an inflationary shock that is positive in the short term, but negative in the longer term.

[70] The results for Montréal and Québec City are exceptions: inflation's impact on real housing prices is positive whatever the horizon.

[71] With a positive effect in the long term, Montréal and Québec City impulse responses differ from those of the other areas.

Figure 13

Cumulative NHPI Impulse Response to 1% CPI Shock
(Major Urban Centres – Reference Model)

Major urban centres

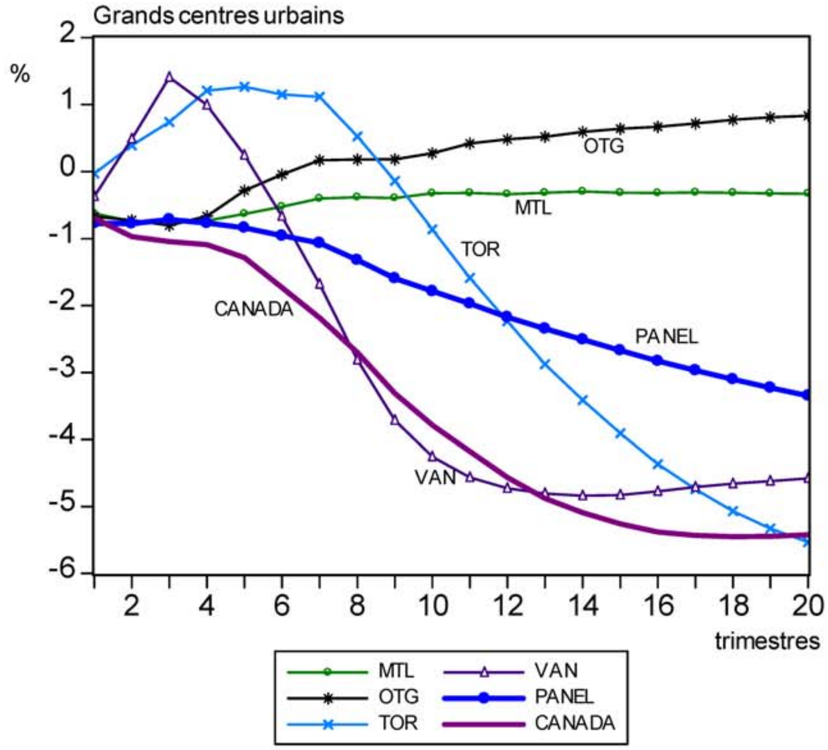
Quarters

Other urban centres

Quarters

Figure 13

Réponse dynamique cumulée de IPLN à un choc de 1% sur IPC
(Grands centres urbains; modèle de référence)



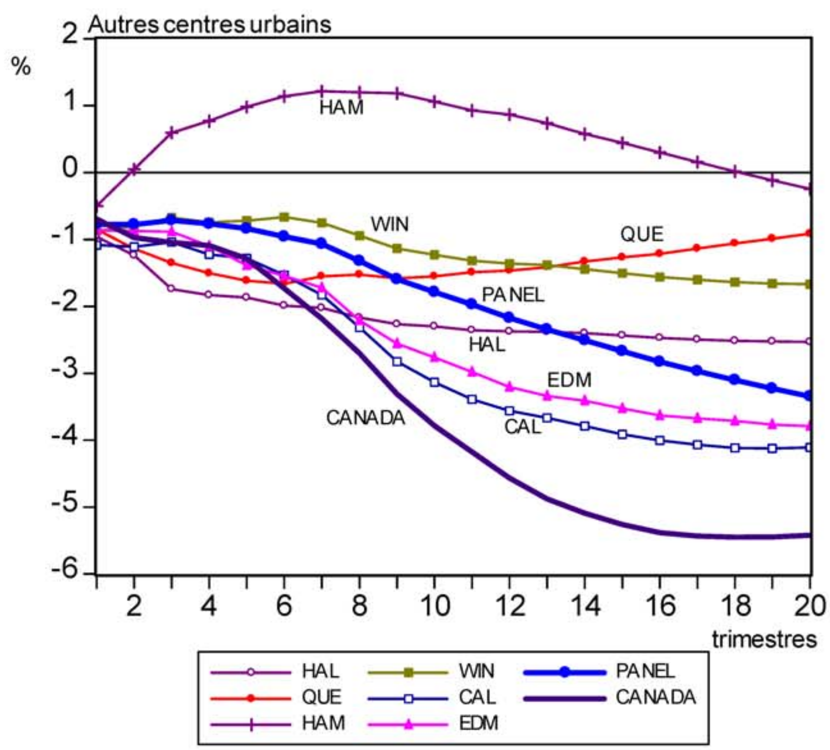


Figure 14

Cumulative HS Impulse Response to 1% CPI Shock
(Major Urban Centres – Reference Model)

Major urban centres

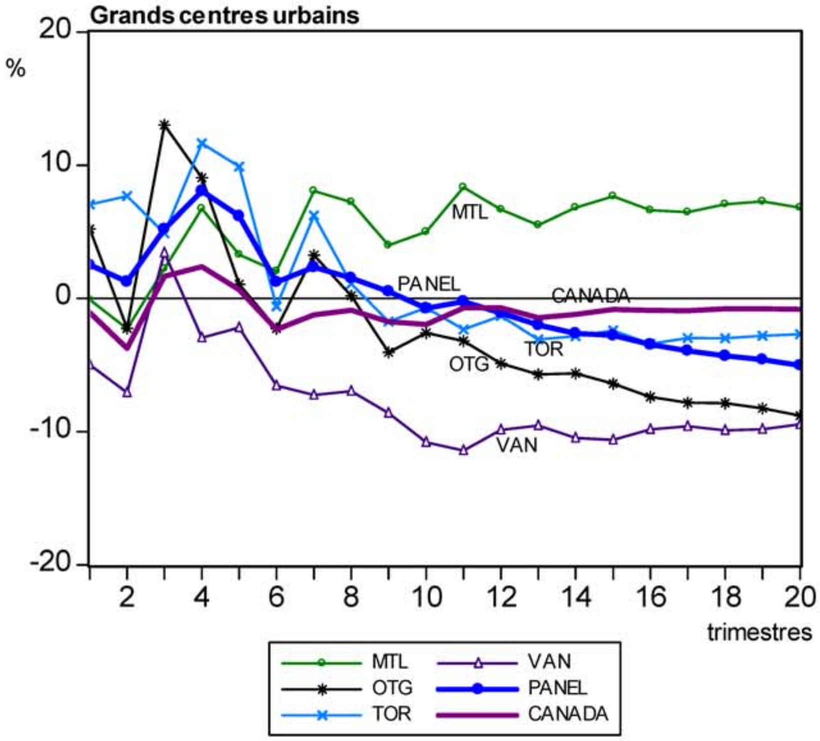
Quarters

Other urban centres

Quarters

Figure 14

Réponse dynamique cumulée de HS à un choc de 1% sur IPC
(Grands centres urbains; modèle de référence)



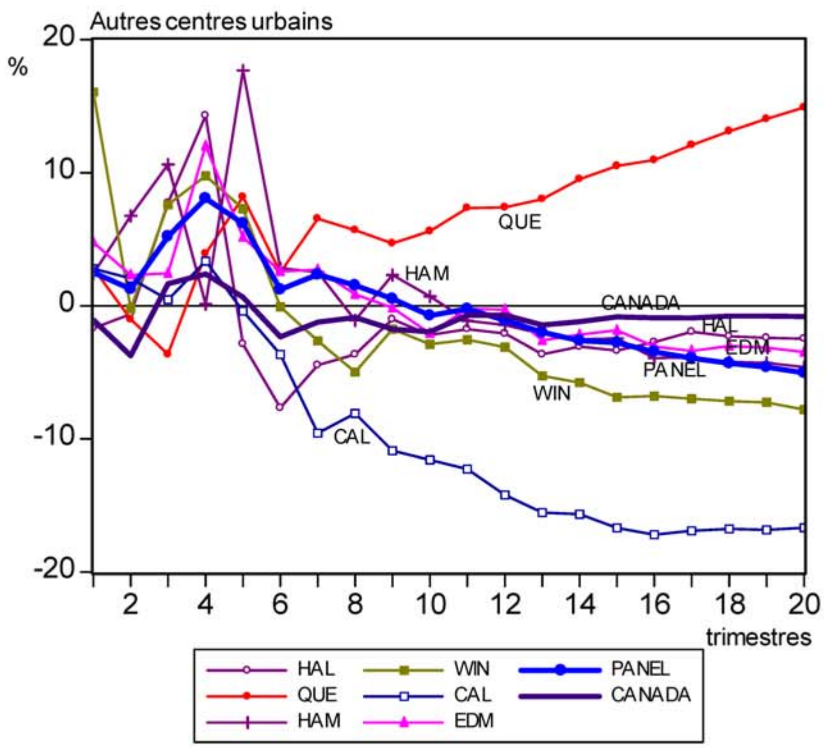


Figure 15

Cumulative NHPI Impulse Response to 1% CC Shock
(Major Urban Centres – Reference Model)

Major urban centres

Quarters

Other urban centres

Quarters

Figure 15

Réponse dynamique cumulée de IPLN à un choc de 1% sur CC
(Grands centres urbains; modèle de référence)

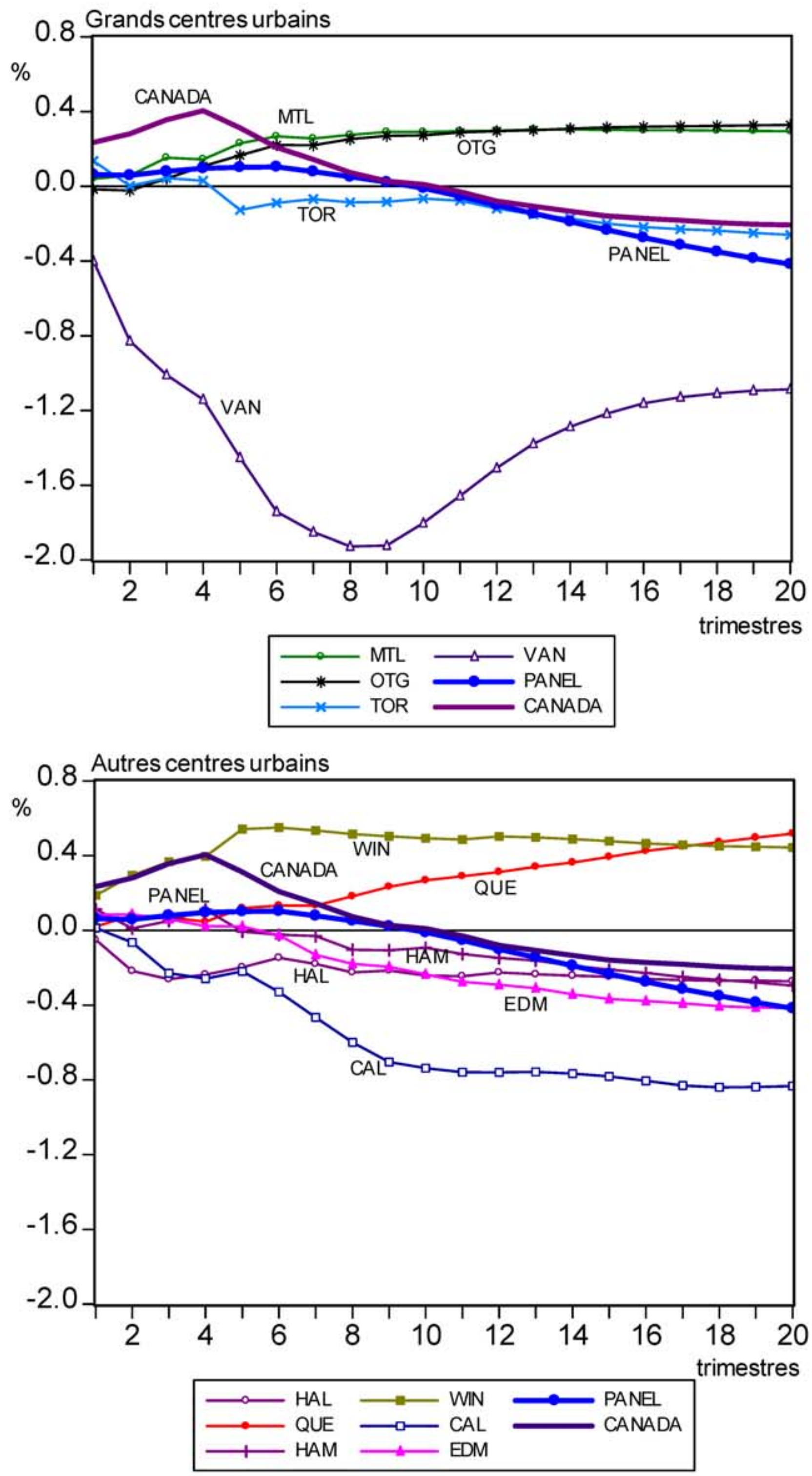


Figure 16

Cumulative HS Impulse Response to 1% CC Shock
(Major Urban Centres – Reference Model)

Major urban centres

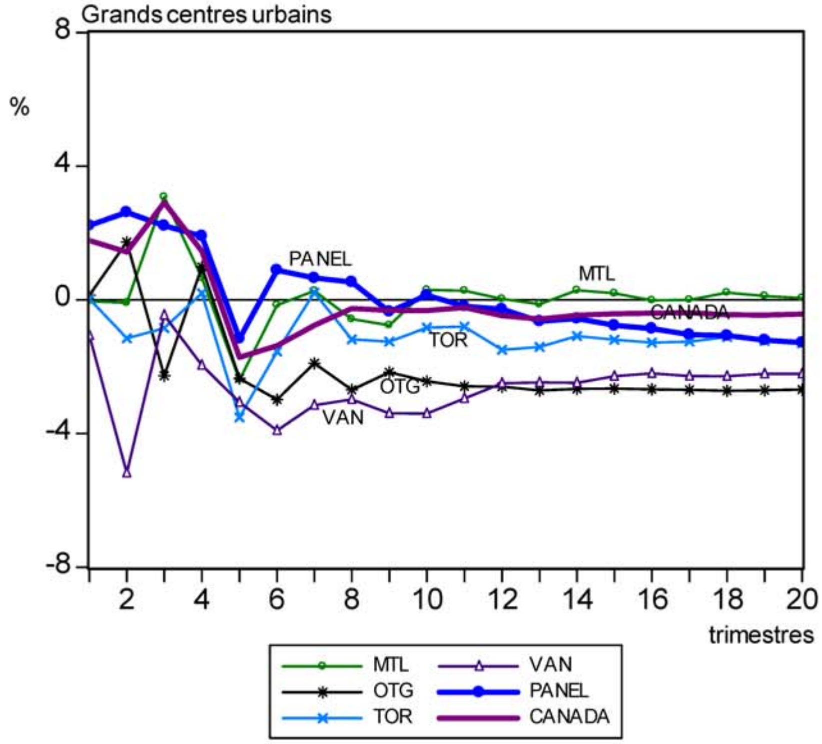
Quarters

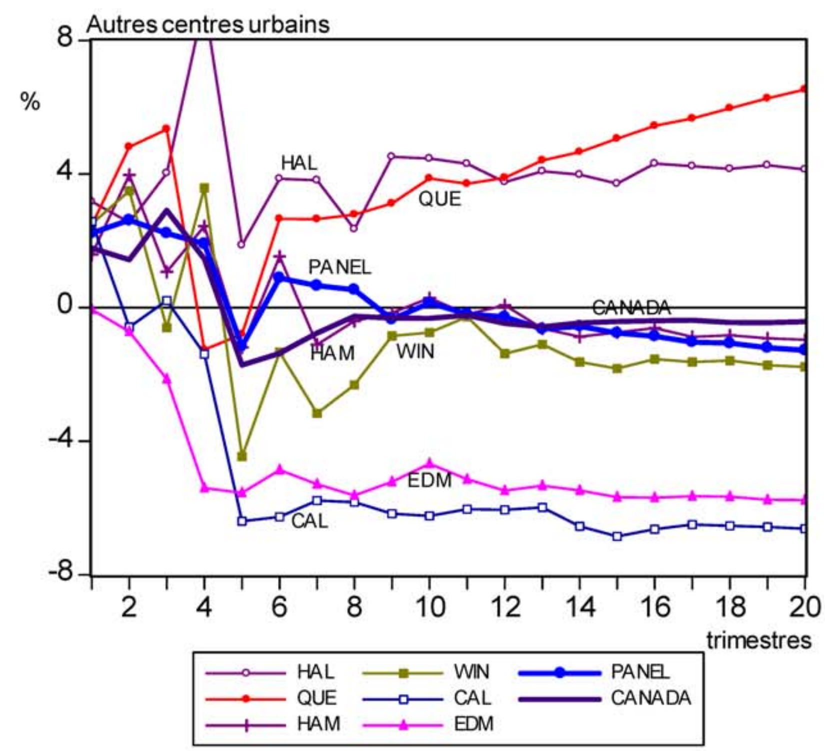
Other urban centres

Quarters

Figure 16

Réponse dynamique cumulée de HS à un choc de 1% sur CC
(Grands centres urbains; modèle de référence)





Our combined results, as illustrated by Figures 15 and 16, indicate that the effect of real construction cost shocks on real housing prices and housing starts is usually weak and not significantly different from zero.[72] It may be that shocks in construction costs have little impact. But it is also likely that our VAR model is unable to properly identify the role played by construction costs. The literature on the subject testifies to this difficulty. The task seems even more difficult when we try to simultaneously consider demand and supply factors. Notwithstanding this warning, our panel estimations show that a shock in construction costs increases new housing prices and housing starts for horizons of less than two years, but that the subsequent effect becomes negative.[73] The metropolitan areas of Western Canada exhibit more sensitivity (negative effects) than the other CMAs.

A shock in housing starts stimulates real new housing prices as well as housing starts (Figures 17 and 18). The size of the impulse response is due more to the size of the typical shock considered than to the intrinsic sensitivity of housing prices. With respect to the effects on housing prices, impulse responses are very similar by region. The panel estimations imply that a typical shock (of a standard deviation) raises real housing prices by 2.9% after five quarters and persists.[74]

The reaction of housing starts to the same shock is similar. Housing starts react positively to a housing start shock. After the first quarter, the effects are stable and very similar from one area to another. According to the panel estimations, a 1% shock implies an increase of roughly 1% in housing starts after one quarter. The effects endure for a very long time, giving plausibility to some of the over- or under-building behaviours that might explain some persistent imbalances in the real estate market.

Let us now examine the new housing price impulse response to a shock in this same variable (NHPI). With respect to this shock, let us consider the effect of an urban development regulation or building standards. Figure 19 indicates that such a shock clearly and strongly stimulates housing prices. According to the panel estimations, an "innovation" corresponding to a one-percentage-point rise in housing prices implies a cumulative real new housing price reaction of 2.4% after one year and 2.3% after five years. The effect is not only substantial, but also very persistent. This finding proves very sound; this, therefore is a fundamental characteristic of the residential real estate market. Estimations specific to each CMA indicate that impulse responses vary from one CMA to another. Thus, Toronto shows a much stronger response to the shock and, despite this, a very persistent response. Vancouver exhibits just as strong a dynamic reaction in the short term, but much less persistent. Montréal, Winnipeg and Halifax

[72] This does not imply that increases in construction costs do not have a direct effect on housing prices or housing starts, but that the construction cost increases not produced by variations in the other variables taken into consideration have relatively few effects. However, generally speaking, real construction costs seem to react little to the different variables present in the model; this is what is indicated by the Granger causality tests we performed. This suggests that existing imbalances in the real estate market have little chance of being reduced by an adjustment in construction costs.

[73] One explanation of this pattern would be that, in the short term, builders succeed in passing on the higher costs to purchasers, at least in part, but that in the longer term, this results in reducing demand for housing and, consequently, housing prices.

[74] Halifax is the exception with almost zero sensitivity.

Figure 17

Cumulative NHPI Impulse Response to 1% HS Shock
(Canada and CMAs – Reference Model)

Major urban centres

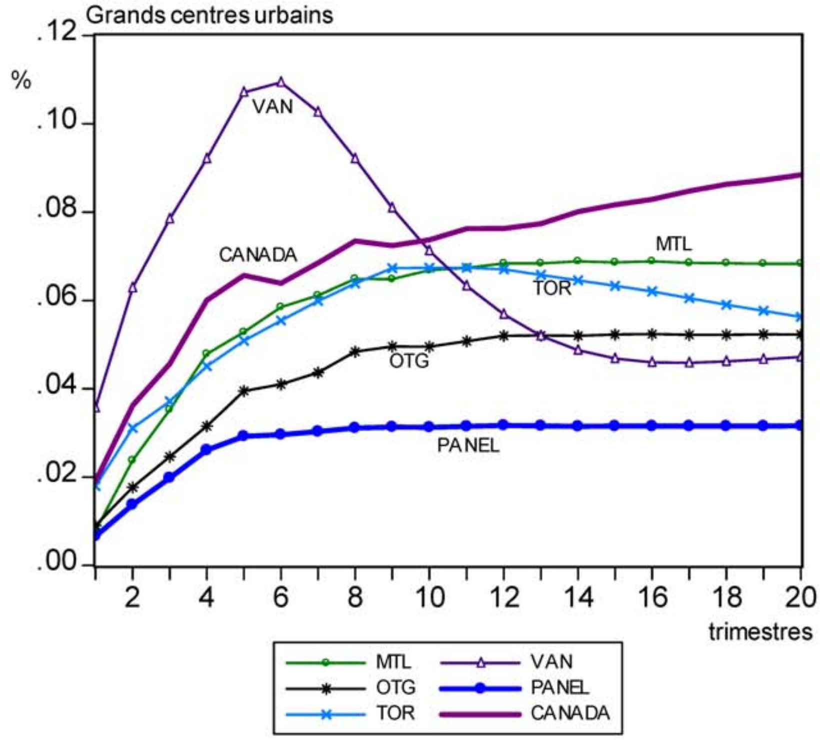
Quarters

Other urban centres

Quarters

Figure 17

Réponse dynamique cumulée de IPLN à un choc de 1% sur HS (Canada et RMR; modèle de référence)



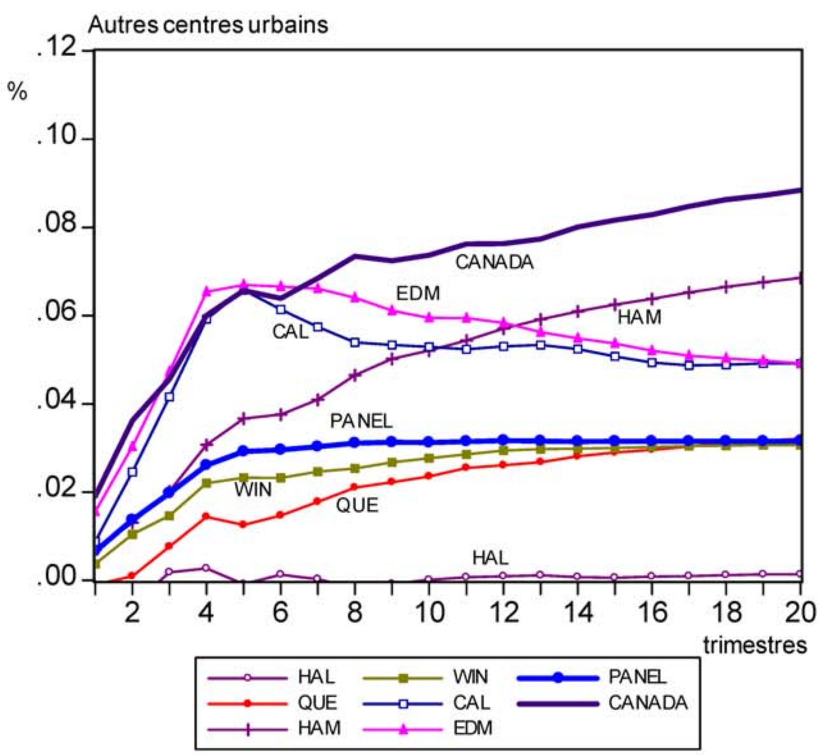


Figure 18

Figure 18

Cumulative HS Impulse Response to 1% HS Shock
(Major Urban Centres – Reference Model)

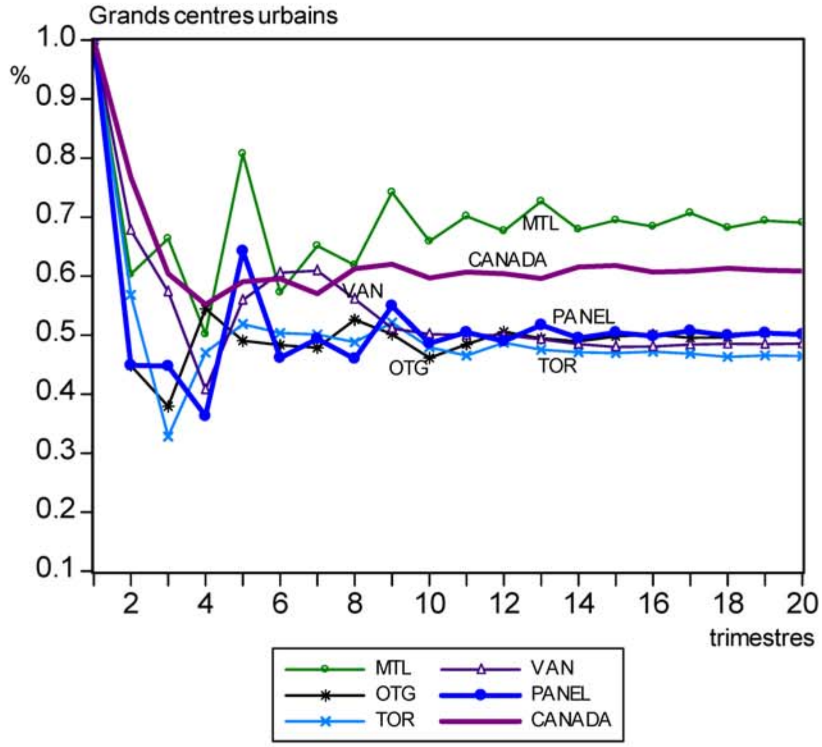
Major urban centres

Quarters

Other urban centres

Quarters

Réponse dynamique cumulée de HS à un choc de 1% sur HS
(Grands centres urbains; modèle de référence)



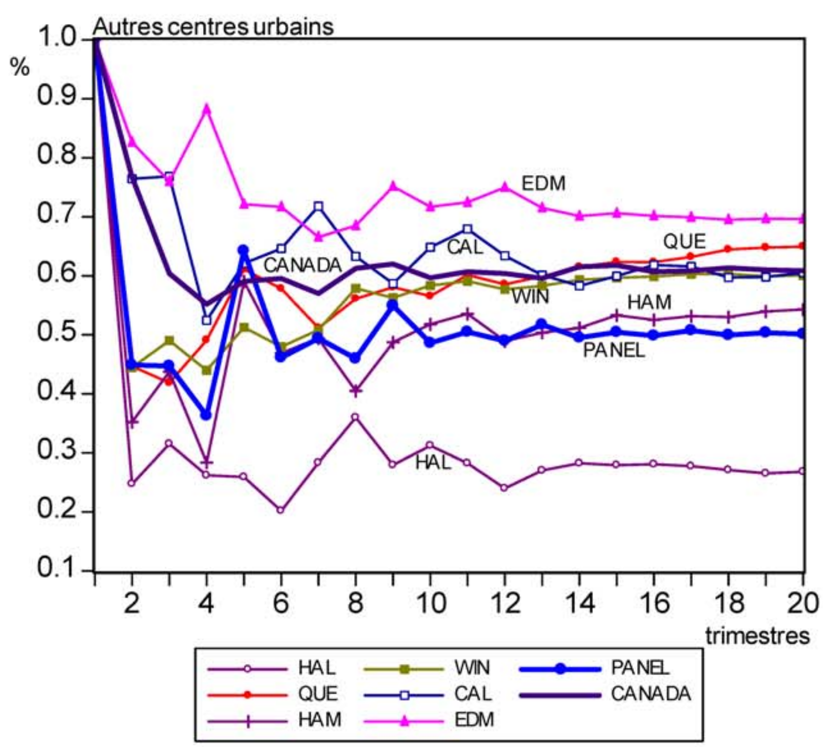


Figure 19

Figure 19

Cumulative NHPI Impulse Response to 1% NHPI Shock
(Canada and CMAs – Reference Model)

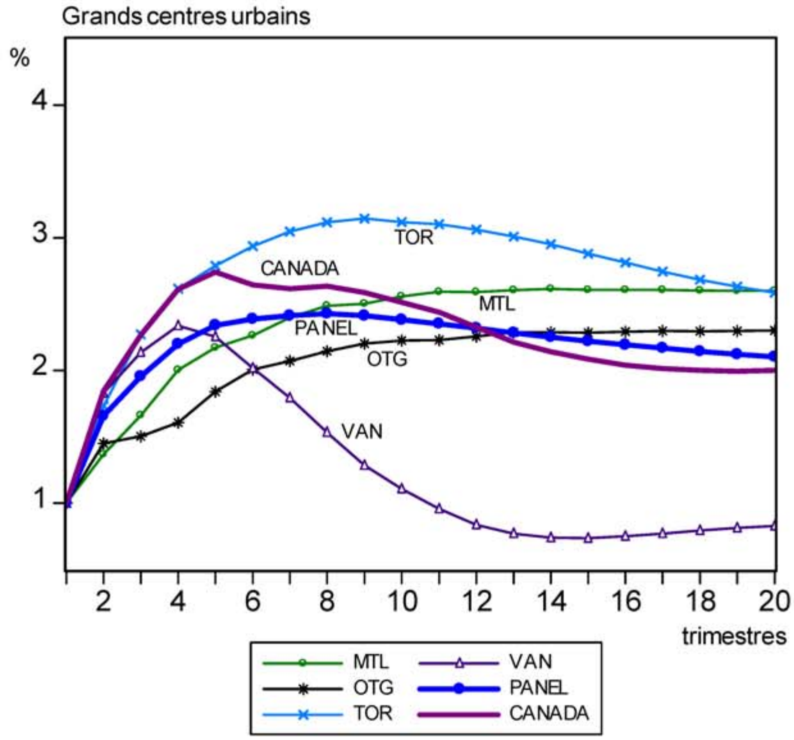
Major urban centres

Quarters

Other urban centres

Quarters

Réponse dynamique cumulée de IPLN à un choc de 1% sur IPLN (Canada et RMR; modèle de référence)



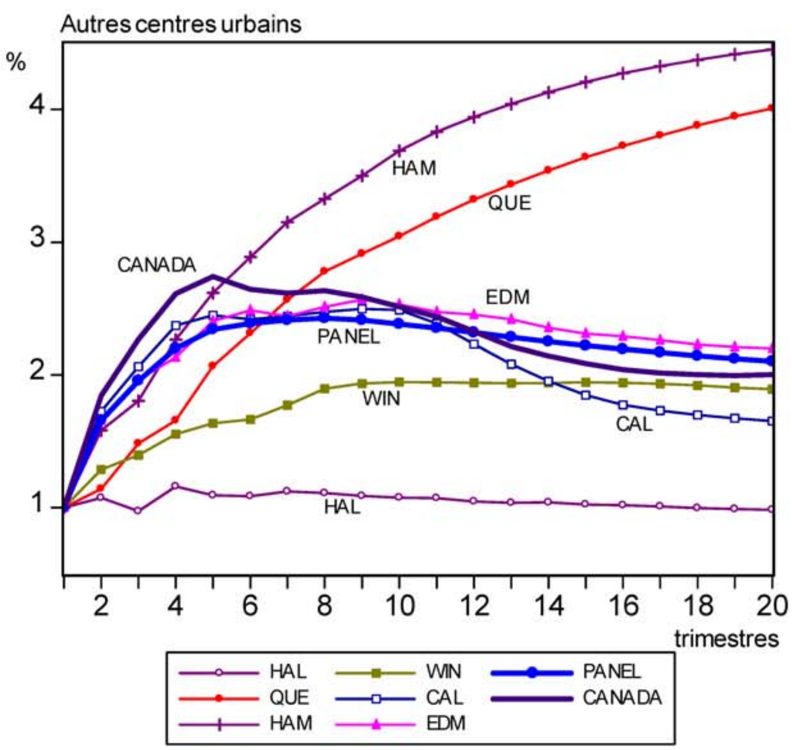


Figure 20

Figure 20

Cumulative HS Impulse Response to 1% NHPI Shock
(Major Urban Centres – Reference Model)

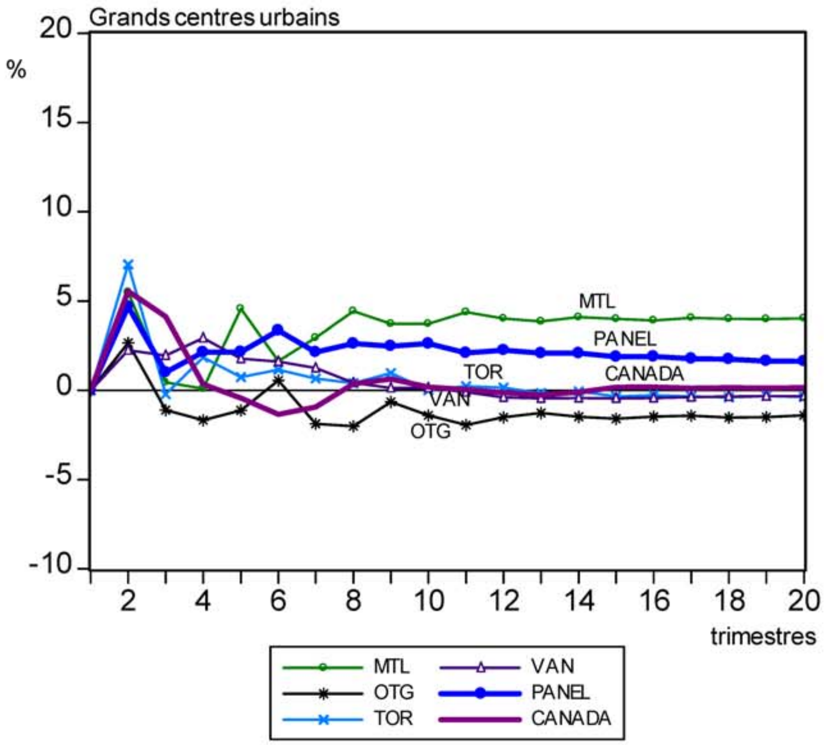
Major urban centres

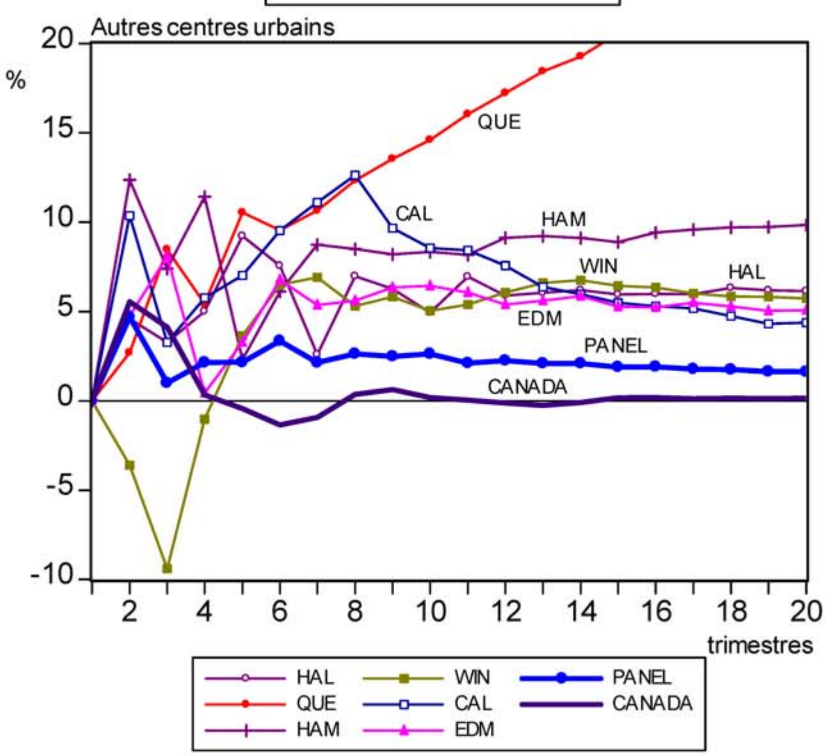
Quarters

Other urban centres

Quarters

Réponse dynamique cumulée de HS à un choc de 1% sur IPLN
(Grands centres urbains; modèle de référence)





have the weakest dynamic effects among the CMAs, but these effects are nonetheless substantial and persistent. These impulse responses are compatible with the idea that housing price increases lead homebuyers to expect future hikes in housing prices, which reduces real immovable investment cost and stimulates demand and housing prices. As we were saying earlier, this strong, persistent dynamic reaction implies that reducing existing imbalances in the housing market will take a lot of time. It is compatible with the existence of real estate bubbles.

Figure 20 illustrates the dynamic reactions in housing starts after a shock in real housing prices. Housing construction responds to this shock positively and, generally speaking, persistently. According to the panel estimations, a 1% shock in housing prices produces a 2.3% increase in housing starts after one year and 2.1% after five years. The impulse responses specific to the Toronto, Vancouver and Ottawa-Gatineau areas exhibit less persistence. This finding is compatible with the idea that homebuilders are encouraged to build more by higher profit margins. However, insofar as new construction accounts only for a minimal fraction of the housing stock, reducing housing market imbalances would still take time (Meen 2001).[75]

7.3 What are the primary determinants of historical variations in housing prices?

Having analysed how the six variables in the VAR panel model reacted to the different shocks, let us now examine the contribution of these shocks to historical variations in both real new housing prices and housing starts. Figures 21 and 22 summarize these contributions. They compare the contributions of each of these shocks over a five-year horizon.[76]

Immediately noticeable in Figure 21 is the very strong contribution to housing price variations by its own shocks (shocks in the NHPI). This undoubtedly reflects the difficulty the model has in predicting the quarterly real housing price variation rate.[77] It is obviously exacerbated in a panel (common) model where the model forces the dynamic structure to be the same for all areas. This contribution may refer to the effects of real property wealth (realized and anticipated) and to the effects of independent shocks to land prices. But above all, it has a residual character: these "innovations" have origins that cannot be associated with the other determinants.

Figure 21
THE CONTRIBUTION OF SHOCKS TO HISTORICAL REAL HOUSING PRICE VARIATIONS BY AREA (CMAs, Panel, Canada)

NHPI CONTRIBUTION TO NHPI

HS CONTRIBUTION TO NHPI

EMP'T CONTRIBUTION TO NHPI

Y90 CONTRIBUTION TO NHPI

[75] The impulse responses also reflect the fact that increases in housing prices create a wealth effect that stimulates housing demand and thus housing prices.
[76] Presentation of contributions for other horizons provides little additional information.
[77] Even though the model has some difficulties explaining the quarterly new housing price variation rate, simulation exercises show that the model is very successful in predicting the level of housing prices.

CPI CONTRIBUTION TO NHPI

CC CONTRIBUTION TO NHPI

Figure 22
THE CONTRIBUTION OF SHOCKS TO HISTORICAL VARIATIONS IN HOUSING STARTS BY AREA (CMAs, Panel, Canada)

[PMLS] CONTRIBUTION TO HS

HS CONTRIBUTION TO HS

EMP'T CONTRIBUTION TO HS

Y90 CONTRIBUTION TO HS

CPI CONTRIBUTION TO HS

CC CONTRIBUTION TO HS

Figure 21

CONTRIBUTION DES CHOCS AUX VARIATIONS HISTORIQUES DES PRIX RÉELS DES LOGEMENTS SELON LES RÉGIONS (RMR, Panel, Canada)

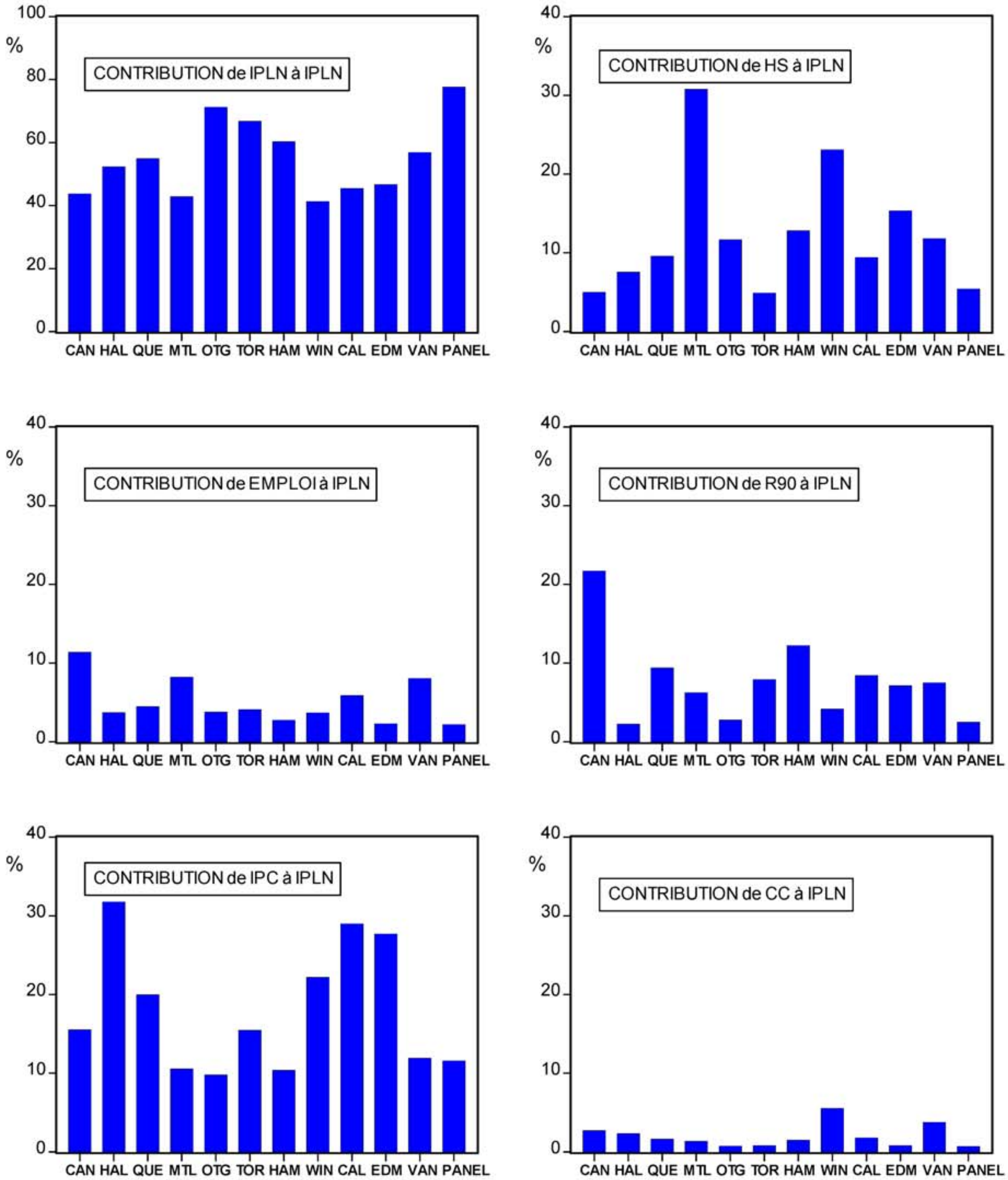
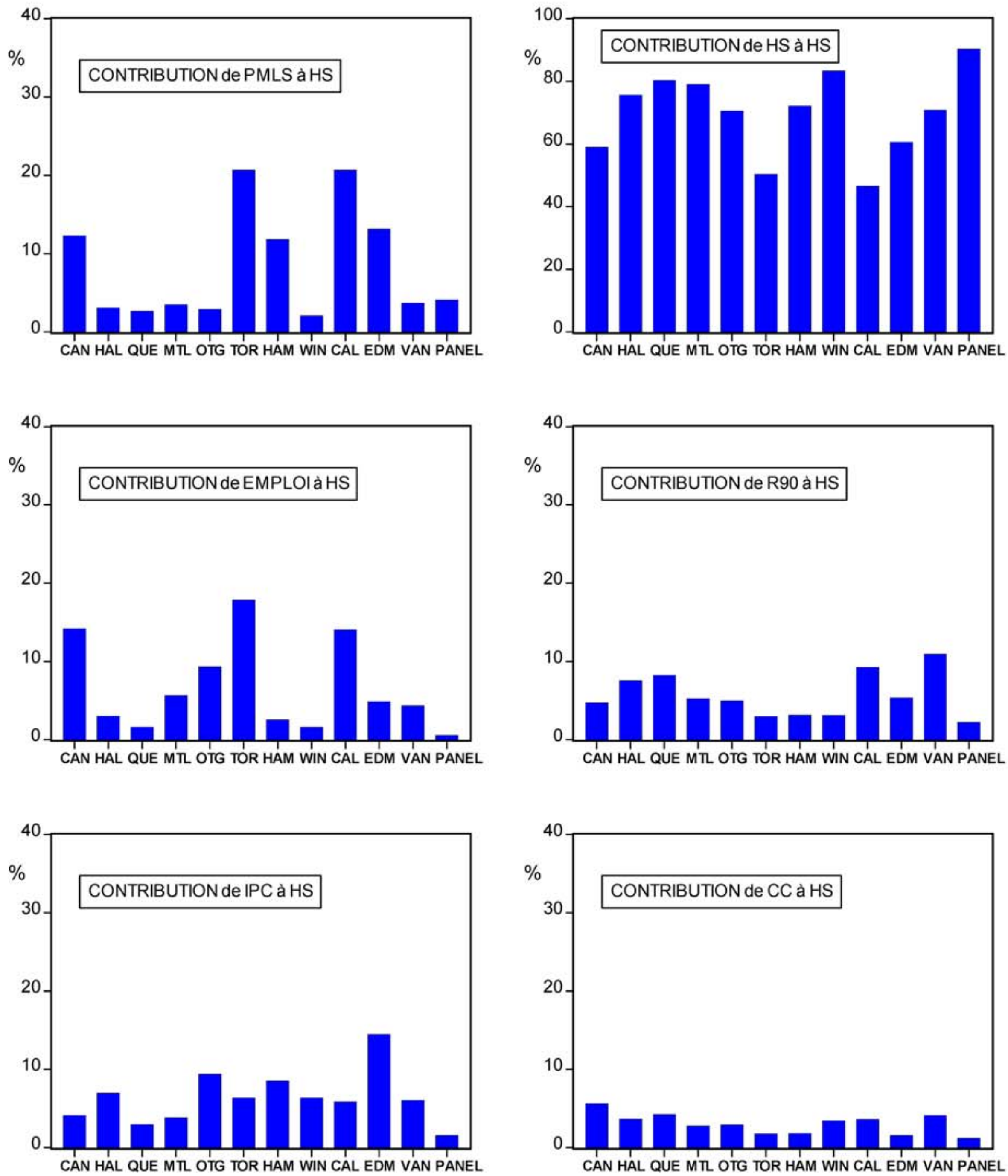


Figure 22

CONTRIBUTION DES CHOCS AUX VARIATIONS HISTORIQUES DES MISES EN CHANTIER SELON LES RÉGIONS (RMR, Panel, Canada)



Among the other shocks, inflationary shocks clearly dominate with contributions of 10 to 32% after five years by area. The estimated contribution is highest in Halifax (32%), Winnipeg (22%), Calgary (29%) and Edmonton (28%). Estimations for the other areas are fairly similar. The panel estimation puts the contribution at 12%, while for Canada, we obtained a 16% contribution. For six of the 10 metropolitan areas considered, inflation constitutes the most significant determinant – except for the determinants' specific shocks. The reasons for this contribution were discussed earlier in this report. The fact that inflation is the major determinant may be surprising. The same result was obtained in a recent study by Tsatsaronis and Zhu (2004) dealing with a panel of 17 countries.

The second-ranking determinant consists of shocks in housing starts (supply factor). Despite low new housing price sensitivity to exogenous housing start variations, the appreciable size of these shocks explains a significant part of historical real housing price variations.[78] On the basis of panel estimations and estimations for Canada, these housing start shocks account for about 5-6% of historical variations in housing prices. For most of the CMAs, the contribution is about 10%. It is 30%, however, for Montréal and 23% for Winnipeg.

For the Canada VAR model, monetary shocks, with a contribution of 22%, were by far the leading determinant of housing price variations. Estimations specific to the various metropolitan areas do not lead to the same conclusion, as the estimated contributions are generally in the range of 6 to 12%.[79] It may be that the monetary shocks were not properly measured. However, monetary shocks remain a significant determinant.[80]

The contribution of non-monetary demand shocks (employment shocks) is smaller than that of monetary shocks. For all the areas considered except one, employment is in 3rd or 4th place in order of importance as a determinant. For Canada, this contribution is situated at 11% for a horizon of five years. For the metropolitan areas, the estimated contributions swing between 2% and a little more than 8%. They are highest for Montréal and Vancouver. These contributions may seem low in comparison with our *a priori* assumptions. In their international study on housing prices, Tsatsaronis and Zhu (2004) reach an equivalent result using household disposable income rather than employment in their VAR model. There is no assurance that it was possible to identify all the employment shocks with the data available.

Lastly, according to our estimations, construction costs are a minor determinant of housing prices. Irrespective of the areas, their contributions are low, most often lower than 2%. The contributions estimated for Winnipeg (5.5%) and Vancouver (3.8%) are a bit higher. For Canada, this contribution was evaluated at 2.7%.

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[78] Housing starts constitute an extremely noisy variable. Consequently, it is very difficult to predict, particularly when it is expressed in quarterly rate of change. This fact likely amplifies the estimated shocks.

[79] The panel estimation implies, for the reasons already mentioned, a contribution that is too weak to be truly plausible. Prediction error variance is too large.

[80] By comparison, the contributions of real interest rate shocks are a bit larger in housing starts (Figure 19).

7.4 Land cost shocks and housing price dynamics

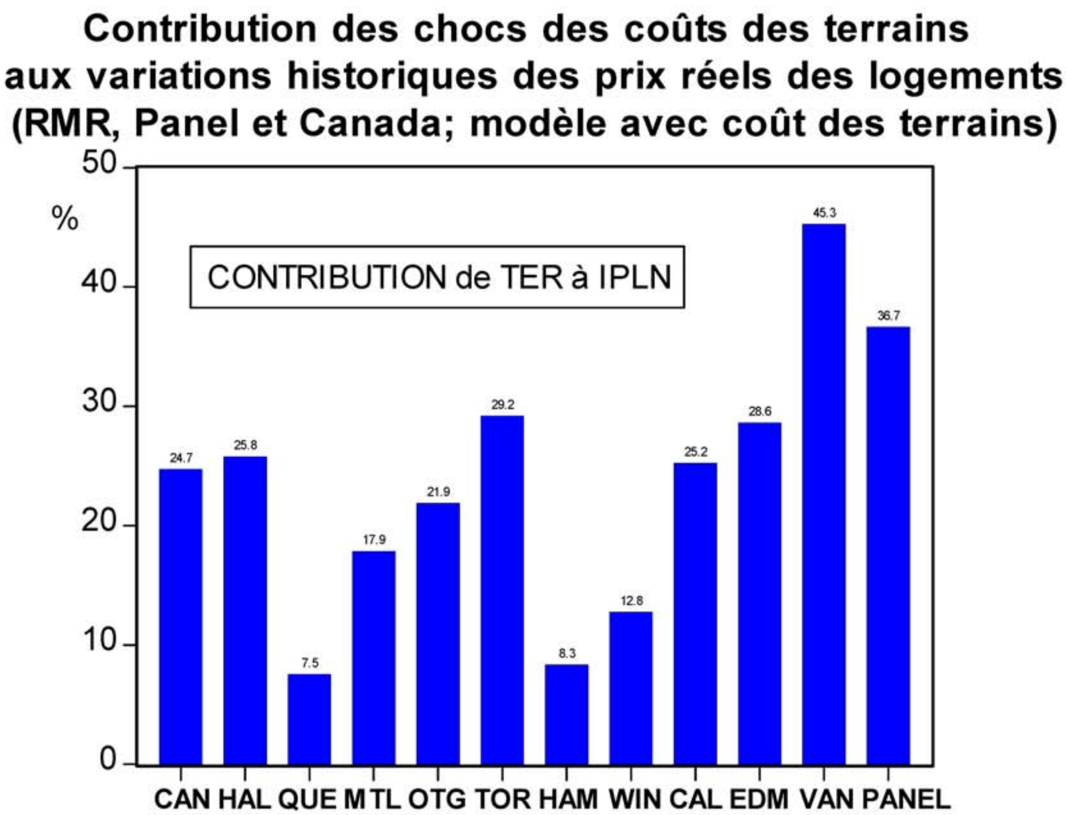
In the reference model, the construction costs variable does not take land costs into consideration. The only indicator available for land costs is the New Housing Price Index sub-index. As already mentioned, this indicator is not ideal, since it measures exit prices rather than entry prices. However, the evolution of land prices has been very different from the evolution of the total NHPI.[81] It is of obvious interest to specifically consider land prices in our analysis of housing price determinants. To what extent do exogenous land price shocks affect housing price dynamics?

Figure 23

The Contribution of Land Cost Shocks to Historical Real Housing Price Variations
(CMAs, Panel and Canada – Model with Land Costs)

LC CONTRIBUTION TO NHPI

Figure 23



[81] Furthermore, the panel data sample indicates that land prices are 33% more volatile than total housing price, when these statistics are expressed as quarterly rate changes (2.4% standard deviation versus 1.8%).

A VAR model that includes land cost as an endogenous variable somewhat increases the VAR model's capability of explaining and predicting the new housing price rate of change (generally we observe a rise of one or two percentage points in R^2). On the other hand, variance decomposition analysis in this augmented model reveals that shocks in (real) land costs contribute to an average of about 25% of housing price fluctuations (Figure 23). The areas where

Figure 24

Réponse dynamique cumulée de IPLN à un choc de 1% sur TER
(RMR, Panel et Canada; modèle avec TER)

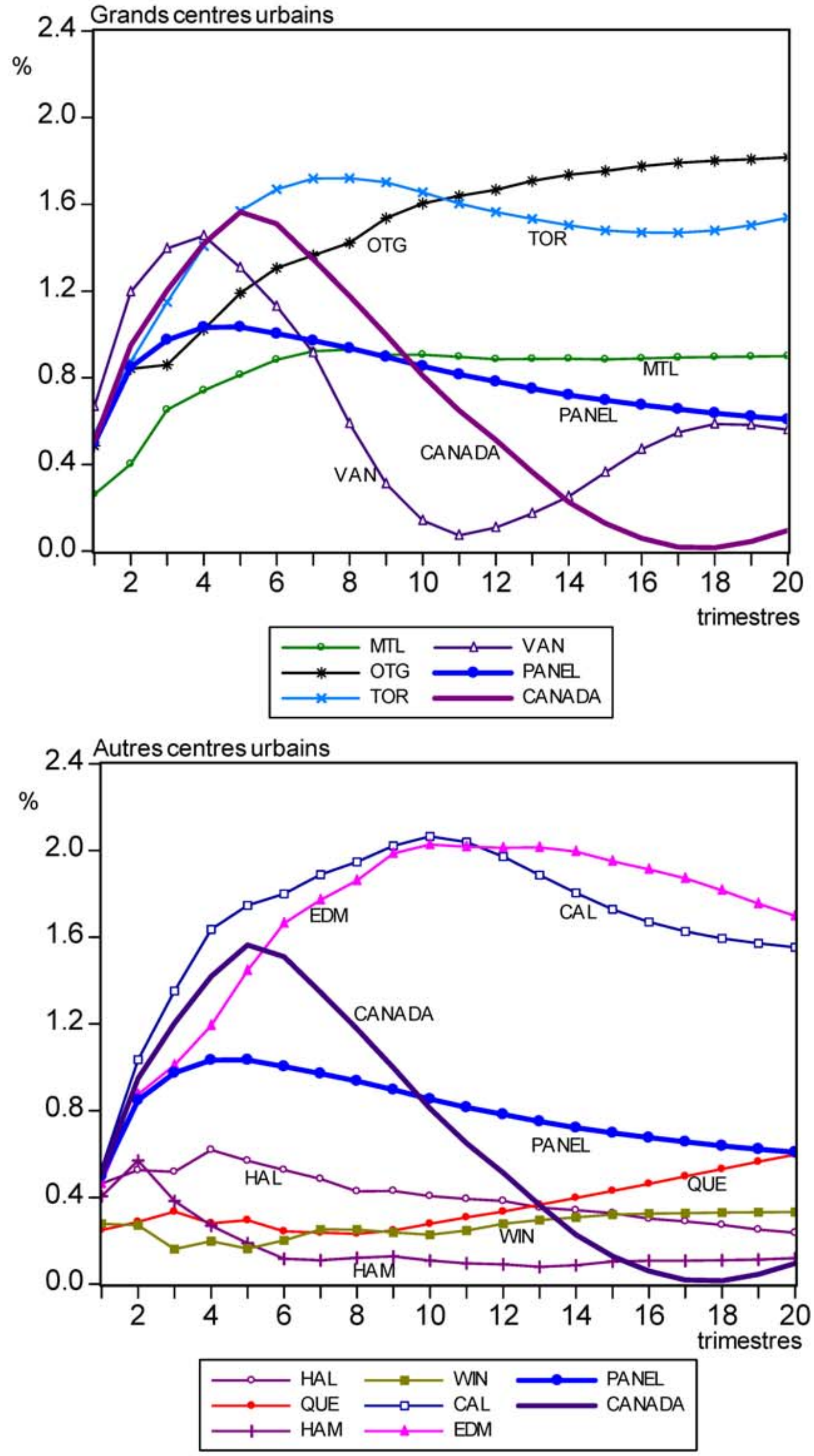


Figure 24

Cumulative NHPI Impulse Response to a 1% LC Shock
(CMAs, Panel and Canada – Model with LC)

Major urban centres

Quarters

Other urban centres

Quarters

this contribution is highest are Vancouver (45%), Toronto (29%) and Edmonton (29%). These areas saw large spikes in land prices in the early 1980s as well as in the early 90s. Québec (8%), Hamilton (8%) and Winnipeg (12%) are the metropolitan areas where housing prices seem to have been the least affected by land price shocks. Compared to the reference model, the contribution of shocks specific to housing prices is substantially smaller. The contributions of the other shocks remain essentially the same.

With respect to the impulse responses of real housing prices to a shock in real land prices, we observe in Figure 24 that responses vary considerably from one area to another. They are substantial in Vancouver, Toronto, Edmonton and Calgary.[82] They are relatively weak in Québec City, Hamilton, Winnipeg and Halifax. The cumulative response from the panel estimations provides a very good summary of the effects' dynamic profile. A shock on land price raises housing prices for five quarters, the point at which the maximum cumulative impact is reached. Afterward, the effects are somewhat reduced. These shocks prove to be much less persistent than shocks specific to housing prices, although this may differ from one metropolitan area to another. This description of land price shock impulse responses is very similar to what we observe nationally.

Our land cost measurement is not ideal. Therefore, these results must be interpreted with caution. Nevertheless, it does seem that exogenous shocks to land prices contribute appreciably to land price fluctuations in a majority of metropolitan areas.

7.5 Stock market prices as a determinant of housing price variations

The very wide fluctuations experienced by stock markets in the last ten years drew analysts' attention to the question of these movements' effects on housing demand and prices. To what extent did the wealth effect created by the strong surge in stock exchange indexes during the second half of the 1990s contribute to the variations in real housing prices? What were the effects, on these prices and on real estate activity, of the strong market correction in the early years of the 21st century?

To answer these questions, we included a seventh variable in the reference VAR model representing Canada's main stock exchange index, the Toronto Stock Exchange's TSX (formerly called the TSE 300), obviously expressed in real terms. This model was estimated for each of the metropolitan areas and the panel (combined CMAs).

Figure 25 presents the real new housing price impulse response to a shock in the TSX.[83] In it, we observe a positive impulse response in the vast majority of cases. For the panel estimations, the maximum cumulative response is reached after six quarters and corresponds to a rise of a little more

[82] The responses in these CMAs are very persistent, except in Vancouver.
[83] As the TSX is level in the VAR and the shocks have been standardized to permit comparisons, the level of the ordinate values in the chart cannot be interpreted in simple terms.

Figure 25

Cumulative NHPI Impulse Response to a Standard Deviation TSX Shock
(CMAs, Panel and Canada – Model with TSX)

Major urban centres

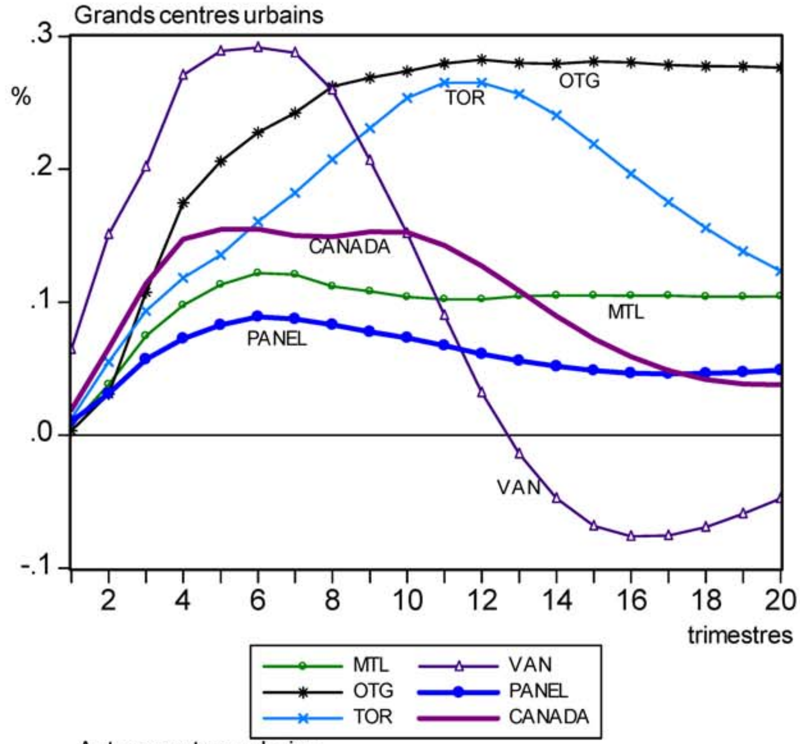
Quarters

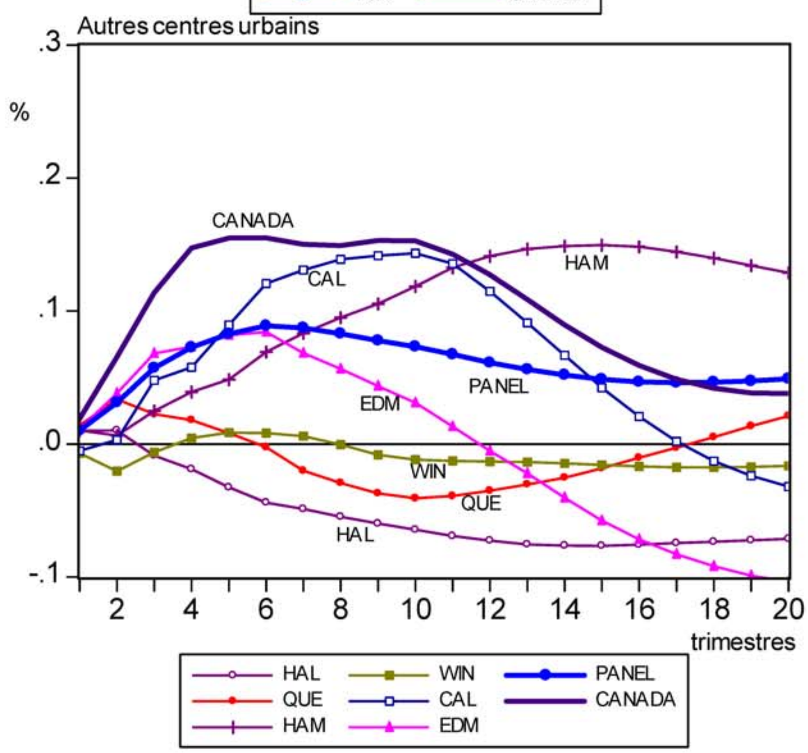
Other urban centres

Quarters

Figure 25

Réponse dynamique cumulée de IPLN à un choc d'un écart-type sur TSX (RMR, Panel et Canada; modèle avec TSX)





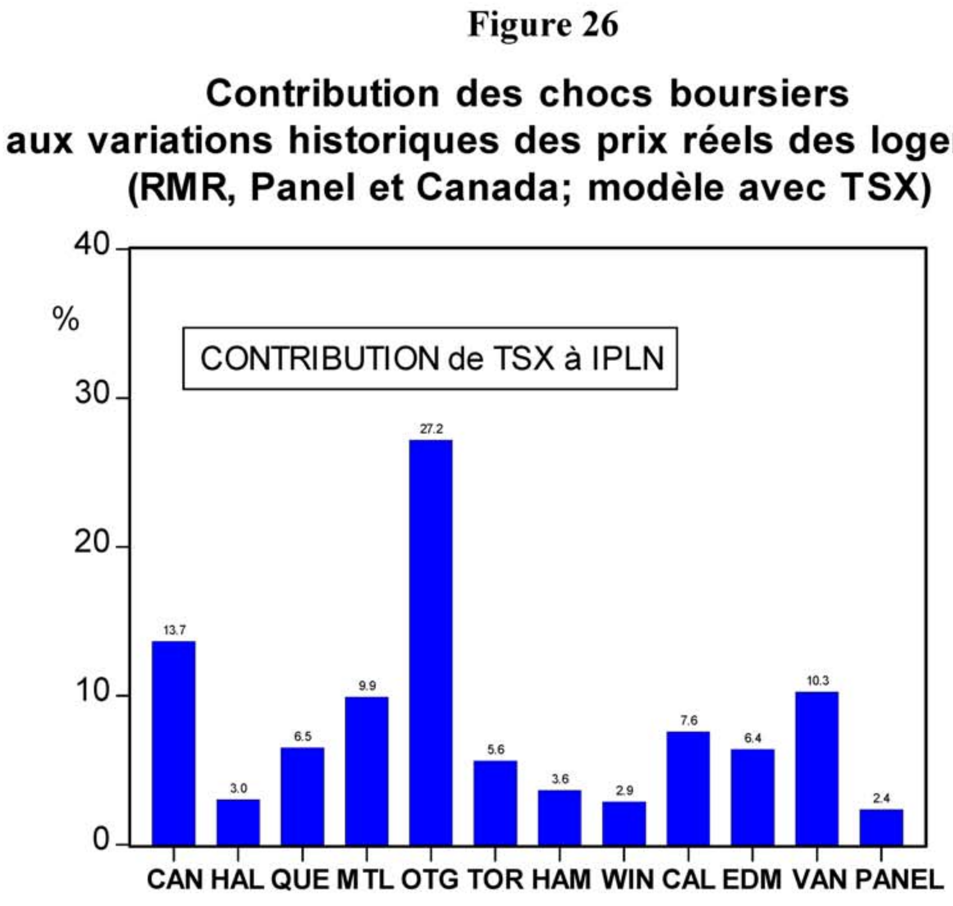
than 8.5% in housing prices. The estimated effects are greatest for the Vancouver, Toronto and Ottawa-Gatineau metropolitan areas. On the other hand, negative impulse responses are estimated for Halifax, Québec City and Winnipeg over several horizons and, in this respect, the responses are not very plausible.

As illustrated in Figure 26, the contribution of shocks in stock market prices on historical real housing price fluctuations varies, by area, from 2 to 10%, Ottawa-Gatineau (27%) being the exception. It is substantial in Vancouver (10%) and Montréal (10%). In almost all the areas, this contribution is higher than the contribution corresponding to employment shocks. Nationally, the contribution was 14%.

Figure 26

Contribution of Stock Market Shocks to Historical Real Housing Price Variations
(CMAs, Panel and Canada – Model with TSX)

TSX CONTRIBUTION to NHPI



In his international study, Sutton (2002) concluded that stock market prices played a major role in housing price variations in most countries, including Canada, and that this role seemed to be as significant as the role of employment and interest rates. Our findings corroborate Sutton's findings. However, it is advisable to interpret these results with great caution. As mentioned earlier, stock market prices are a leading indicator of economic activity. This lead is more closely related to expectations regarding future economic outlooks in the stock market indexes than to the wealth effects that their variations imply. This fact can make it difficult to properly distinguish shocks that are products of stock market prices from shocks that are related to economic activity, income and even housing prices.[84] In addition, the empirical literature on stock market wealth effects suggest that these effects are fairly modest in normal situations.[85] Lastly, the impulse response functions we estimated suggest a very rapid response by housing prices to stock market shocks. Here again, these short impact time intervals seem suspect.

All in all, even though our findings suggest that stock market shocks are a significant determinant of housing price variations, we prefer to maintain a healthy scepticism with regard to the real scope of these assessments.

7.6 Effect of housing prices on employment and consumption

The rapid growth recently observed in housing prices produced a marked reappraisal of household residential wealth. It is essentially through these wealth effects, which impact household consumption, that housing prices impact economic activity (OECD 2004). This question about the effect of housing price fluctuations on consumption and, more broadly, on economic activity has gripped the attention of researchers and analysts for several years (Case, Quigley and Shiller 2001; Girouard and Blöndal 2001; Desnoyers 2001; Boone and Girouard 2002; Tremblay and Pichette 2003 and OECD 2004). For Canada, the OECD (2004) estimated a 3% short-term and 6% long-term marginal propensity to consume real property wealth. The estimations by Tremblay and Pichette (2003) are even higher.

In our model, these real property wealth effects on economic activity may be associated with the effect of housing price shocks on employment (reference model) or on retail sales in a variant of the reference model. Our analysis is highly limited by the data available for the metropolitan areas. Retail sales, expressed in real terms, constitute an indicator closely linked to household consumer spending. Figure 27 presents housing price contributions to historical fluctuations in employment and retail sales.[86]

The contribution of housing price shocks to employment variations was estimated at 8.1% nationally (Canada). In the metropolitan areas, the estimated contributions are between 1.7% and 12.5%. They are highest in Hamilton (12.5%, a result that is difficult to explain), Calgary (6.3%) and Vancouver (5.4%). With respect to the contribution of housing prices to retail sales variations, the estimations are a bit lower, at 4.3% for Canada, 2.1% in Montréal, 2.8% in

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[84] A recent study by Borio and McGuire (2004) examines parallels between the cyclical peaks in share prices and housing prices. Their findings conclude that share prices lead housing prices during expansionary phases.
[85] Empirically, the estimated wealth effect can be lessened by a substitution effect; rising stock market prices prompt households to invest in the stock market rather than in real estate.
[86] These estimated contributions are derived from two variance decomposition analyses, one based on the reference model, including employment as an economic activity indicator, the other based on a variant of the model using retail sales in place of employment. In view of the period covered by our study, statistics on retail sales are available for only four metropolitan areas, namely Montréal, Toronto, Winnipeg and Vancouver.

Toronto, 1.4% in Winnipeg and 3.6% in Vancouver. On the basis of these figures, it appears that housing prices are a substantial determinant of employment and household consumption. Obviously, these evaluations are linked to the accurate identification of structural shocks.

Figure 27

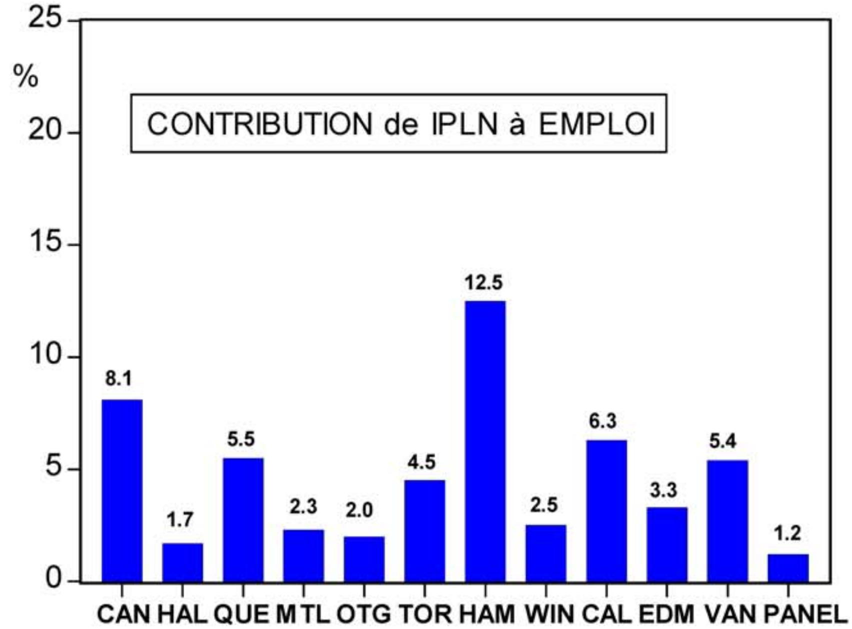
Residential Wealth Effects on Employment
and Real Retail Sales by Area

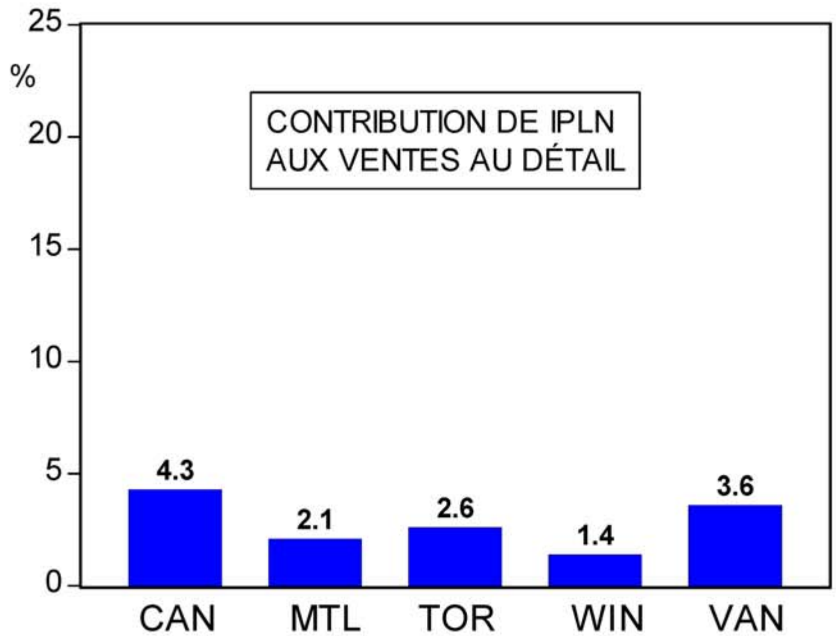
NHPI CONTRIBUTION to EMPLOYMENT

NHPI CONTRIBUTION to RETAIL SALES

Figure 27

**Effets du patrimoine résidentiel sur l'emploi
et les ventes de détail réelles selon les régions**





8. CONCLUSION

This study looked at the determination of housing prices in Canada. The empirical analyses were performed for metropolitan areas in particular, but also at the national level, considering both factors that act on supply and factors that act on demand. We primarily sought to determine and analyze the dynamic reaction of real housing prices to shocks in the main determinants and to assess each one's relative significance in historical housing price variations. Our approach also enabled us to explore an associated question. It relates to the real property wealth effects that housing price fluctuations imply for household spending and, more broadly, for the levels of economic activity in the regions.

We performed a fairly comprehensive review of recent empirical literature relating to the determination of housing prices, specifically literature on metropolitan areas or that addressed some of the themes we were to explore. One conclusion emerges from it. The recent studies leaned heavily toward using, as analysis framework, either error correction models to examine the determinants' direct effects, or vector autoregression (VAR) models when it came to analyzing the question of the various determinants' dynamic effect in a context of general equilibrium.

Our analysis used quarterly data covering the period from 1972 to 2003 nationally, and 1975 to 2003 for urban agglomerations. We built a database containing the statistical series relevant to our study. In this regard, there were as many constraints relating to metropolitan area data availability as there were vis-à-vis historical breaks in these statistical series. This database is a valuable contribution of this project.

Our empirical analysis framework is a vector autoregression (VAR) model. The reference VAR model contains six endogenous variables or determinants: real housing price, housing starts, employment, real interest rate, inflation and real construction costs. Variant reference models also include real land cost, the TSX stock market index and real retail sales. The metropolitan area estimations are probably sensitive to our sample's limited size. To overcome this problem, we performed a panel estimation of the metropolitan areas as a whole. It served as a basis for comparing the results of the estimations specific to each of the urban centres.

Despite the small sample size compared to the number of parameters to be estimated, the national findings proved to be relatively precise and most interesting. It appears that monetary shocks (or real interest rate) are the primary historic determinant of housing price variations in Canada over the period under consideration. Monetary shocks explain roughly 22% of the variations.[87] More surprising is inflation's very powerful contribution — 15% in our preferred model. The impact of inflation on housing prices is clearly negative.[88] In the recent context of stable, low inflation, one might expect that real housing prices would tend to be more stable and see higher growth. Employment shocks, contributing to 11% of variations in real housing prices, prove to be an important determinant, but weaker than anticipated at the outset. Lastly, the two supply factors

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[87] Refer to Figure 4 for these variance decomposition results.

[88] This conclusion contradicts the very well-rooted opinion that inflation fosters real estate speculation above all else and, thereby, stimulates growth in real housing prices.

considered, housing starts and real construction costs, are minor determinants according to our findings.

In some complementary estimations we see that unanticipated variations in land costs are probably a major determinant of housing prices, as shown by the estimated 25% contribution. Like Sutton (2002), we also obtained a significant contribution by stock market shocks (14%). However, we have presented some arguments suggesting that this is an inflated assessment.

As far as the analyses of the metropolitan areas are concerned, our findings show that different urban centres display sensitivity to different shocks and, in several cases, this sensitivity varies appreciably from one agglomeration to another. The same result is observed with regard to the significance of the various shocks in explaining historical variations in housing prices. Generally speaking, the findings for the metropolitan areas suggest that inflation is the dominant factor in most urban centres. This corroborates a conclusion in a 17-country panel study by Tsatsaronis and Zhu (2004) to the effect that inflationary shocks are the most significant explanatory factor. As is the case for Canada, the impulse responses indicate a negative impact of inflation shocks on variations in real housing prices. The contribution of monetary shocks is significant, but weaker than we estimated nationally. A surprising element is the weak contribution of employment as a determinant. This observation corroborates another conclusion by Tsatsaronis and Zhu (2004) suggesting a minor role for household income shocks as housing price determinant. This weak influence is counterbalanced by a greater role for housing starts.[89] Lastly, as for Canada, construction costs play a minor role in metropolitan areas.

In terms of dynamic effects, in all our findings we noted the long time intervals entailed in monetary shocks and the persistent, amplified reaction in housing prices and housing starts to their own specific shocks. These characteristics suggest that the real estate market tends to overreact to shocks and takes a long time to recover its equilibrium. This stylized fact is entirely compatible with the presence of bubbles in the housing market.

In terms of the dynamic effects of shocks, it is possible to make some comparisons between metropolitan areas. Similarities stem primarily from geographical logic. Hence, the Calgary and Edmonton areas often exhibit similar impulse responses, as do Montréal and Québec City. Halifax and Ottawa-Gatineau tend to behave in ways similar to Montréal and Québec City. In some respects, Toronto and Hamilton exhibit related dynamics. Finally, Vancouver's impulse responses differ the most from the behaviours of the other urban centres. Nevertheless, different urban centres display dynamic housing price behaviours that are in many regards unique to them.

The soundness of our results is weakened by the limited number of observations that were available, especially for the metropolitan areas where we are confronted with noisier data. We also performed a panel estimation to try to control the sampling errors. However, the VAR-panel estimations impose the same dynamic structure on metropolitan areas as a whole. It might be interesting to relax a portion of this set of restrictions by making use of a non-standard VAR panel. We might then take advantage of the increased sample of the panel data to test the stability of the results obtained.

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[89] We could ask if, in metropolitan area estimations, housing starts do not overshadow effects that should be attributed to employment.

The idea of verifying whether the impulse responses to the different shocks have not changed over the years is attractive. We have observed many changes in the real estate market in 25 years, particularly with respect to financing instruments. There is reason to believe that these important changes have not been without effect on the behaviour of real estate market stakeholders and, consequently, on housing prices and construction activity. In our study, we were unfortunately forced to assume that behaviours had not changed.

Furthermore, we studied housing prices within the framework of a general equilibrium model. With the same database, it would have been interesting to study the real housing price determinants' direct effects using error correction models. These models capitalize on the existence of long-term relationships in the real estate market. In these models, short-term dynamics are enriched by market imbalance measurements. This approach is particularly attractive in the real estate market context where imbalances have a tendency to persist. In addition, in such a framework, non-standard panel analyses are much easier to perform thanks to the new functionalities of specialized statistical processing software.

BIBLIOGRAPHY

Abraham, J. M. and P. H. Hendershott. "Patterns and determinants of metropolitan house prices, 1977 to 1991," in L. Brown and E. S. Rosengren, ed., *Real Estate and Credit Crunch.* Federal Reserve Bank of Boston Conference Series. 1992. No. 36, 19-42.

Abraham, J. M. and P. H. Hendershott. 1996. Bubbles in metropolitan housing markets. Journal of Housing Research. 7: 191-207.

Aoki, K., J. Proudman and G. Vlieghe. 2001. Why house prices matter. Bank of England Quarterly Bulletin. Winter. pp. 460-468.

Aoki, K., J. Proudman and G. Vlieghe. 2002. Houses as collateral: has the link between house prices and consumption in the U.K. changed. Economic Policy Review. Federal Reserve Bank of New York, May, 8(1): 163-177.

Baffoe-Bonnie, J. 1998. The dynamic impact of macroeconomic aggregates on housing prices and stock of houses: A National and Regional Analysis. Journal of Real Estate Finance and Economics. 17(2): 179-198.

Barot, B. and Z. Yang. 2002. House prices and housing investment in Sweden and the United Kingdom. Econometric analysis for the period 1970-1998. Review of Urban & Regional Development Studies (RURDS). July. 14(2).

Berkovec, J. A. and J. L. Goodman. 1996. Turnover as a measure of demand for existing homes. Real Estate Economics I. 24(4): 421-440.

Boone, L. and N. Girouard. 2002. The stock market, the housing market and consumer behaviour. OECD Economic Studies. 35(2) 197-227.

Borio, C. and P. McGuire. 2004. Twin peaks in equity and housing prices. BIS Quarterly Review. March.

Canner, G., K. Dynan and W. Passmore. 2002. Mortgage refinancing in 2001 and early 2002. Federal Reserve Bulletin. 88. No. 12 (December), pp. 469-481.

Capozza, D. R. and R. Helsley. 1989. The fundamentals of land prices and urban growth. Journal of Urban Economics. 26: 295-306.

Capozza, D. R. and G. M. Schwann. 1989. The asset approach to pricing urban land: Empirical Evidence. Real Estate Economics. 17(2): 161-176.

Capozza, D. R., R. Green and P. H. Hendershott. 1996. Taxes, Home Mortgage Borrowing and Residential Land Prices. Aaron and Gale (ed.). *Fundamental Tax Reform.* The Brookings Institution, Washington D.C. pp. 181-204.

Capozza, D. R 1999. A simple error correction model of housing prices. Journal of Housing Economics. 8: 27-62.

Capozza, D. R., P. H. Hendershott, C. Mack and C. J. Mayer. 2002. Determinants of real house price dynamics. NBER, Working Papers w9262, October, 35 pages.

Case, K. E. and R. J. Shiller. 1989. The efficiency of the market for single family homes. American Economic Review. 79(1): 125-137.

Case, K. E. and R. J. Shiller. 1990. Forecasting prices and excess returns in the housing market. AREUEA Journal. 79(1): 125-137.

Case, K. E., J. M. Quigley and R. J. Shiller. 2001. Comparing wealth effects: the stock market versus the housing market. NBER Working Paper, No. 8606.

Cho, M. 1996. House Price Dynamics: A survey of theoretical and empirical issues. Journal of Housing Research. 7(2): 145-172.

Clayton, J. 1996. Rational expectations, market fundamentals and housing price volatility. Real Estate Economics. 24(4): 441-454.

Deep, A. and D. Domanski. 2002. Housing markets and economic growth: lessons from the US refinancing boom. BIS Quarterly Review. September.

Desnoyers, Y. 2001. L'effet de la richesse sur la consommation aux Etats-Unis. Bank of Canada Working Paper No. 2001-14.

DiPasquale, D. and W. Wheaton. 1996. *Urban Economics and Real Estate Markets.* Prentice-Hall, Englewood Cliffs, NJ.

Dodge, D. 2003. Asset prices and monetary policy, in Policies to Sustain Growth Domestically and Internationally. *S*peech by the Governor of the Bank of Canada, 22 April, Bank of Canada, 11 pages.

Engelhardt, G. V. and J. M. Poterba. 1991. House prices and demographic change, Canadian evidence. Regional Science and Urban Economics. 21(4): 539-546.

Follain, J. R. and O. T. Veltz. 1995. Incorporating the number of existing homes in a structural model of the market for owner-occupied housing. Journal of Housing Economics. 4: 93-117.

Fortin, M. and A. Leclerc. 2000. Demographic changes and real housing prices in Canada. Département d'économique, Université de Sherbrooke, Working Papers No. 00-06, 35 pages.

Fortura, P. and J. Kushner. 1986. Canadian inter-city house price differentials. AREUEA Journal. 14(4): 525-536.

Gallin, J. 2003. The long-run relationship between house prices and income: evidence from local housing markets, Federal Reserve Board, United States. April, 25 pages.

Gavin, W. T. and A. T. Theodorou. 2003. A common model approach to macroeconomics: using panel data to reduce sampling error. Working Paper 2003-045B. Federal Reserve Bank of St-Louis, 28 pages.

Girouard, N. and S. Blöndal. 2001. House prices and economic activity, OECD Working Paper, No. 279.

Glaeser, E. L., J. Gyourko and R. Saks. 2003. Why is Manhattan so expensive? Regulation and the rise in house prices. NBER Working Paper, No. 10124. November.

Glaeser, E. L. 2004. Housing supply. NBER Reporter, National Bureau of Economic Research. Spring: 12-14.

Goy, R. and M. Steele. 1994. Alternative constant-quality price indexes for modest houses and condominiums in Kitchener, Waterloo. Richard Goy Consulting and Department of Economics, University of Guelph, Ontario.

Green, R., S. Malpezzi. 1998. A primer on U.S. housing markets and policy. Working Paper, University of Wisconsin, Center for Urban Land Research.

Hamilton, J. D. 1994. *Time Series Analysis.* Princeton University Press, Princeton, N.J.

Hendershott, P. H. 1980. Real user costs and the demand for single-family housing. Brookings Papers on Economic Activity. 2: 401-444.

Hendry, D. F. 1984. "Econometric Modelling of house prices in the United Kingdom". D. F. Hendry and K. F. Wallis (ed.). *Econometrics and Quantitative Economics.* Basil Blackwell, Oxford.

Hort, K. 1998. The determinants of urban house price fluctuations in Sweden 1968-1994. Journal of Housing Economics. 7(2): 93-120.

Kearns, J. 1979. Inflation, mortgages, and housing. Journal of Political Economy 87: 1-29.

Lamont, O. and J. Stein. 1999. Leverage and house price dynamics in U.S. Cities. RAND Journal of Economics. 30(3): 498-514.

Lastrapes, W. D. 2002. The Real price of housing and money supply shocks: Time series evidence and theoretical simulations. Journal of Housing Economics. 11: 40-74.

Lettau, M. and S. Ludvigson. 2002. Consumption, aggregate wealth and expected stock returns. Journal of Finance. 56: 815-849.

Lettau, M. and S. Ludvigson. 2001. Understanding trend and cycle in asset values: Bulls, bears and the wealth effect on consumption. CEPR Discussion Paper, No. 3104.

Ludvigson, S. and C. Steindel. 1999. How important is the stock market effect on consumption? Federal Reserve Bank of New York Economic Policy Review. July: 29-51.

Maki. D. and M. Palumbo. 2001. Disentangling the wealth effect: A cohort analysis of household saving in the 1990s. Federal Reserve Board Finance and Economics Discussion Series, No. 2001-21.

Malpezzi, S. 1999. A simple error correction model of house prices. Journal of Housing Economics, 8: 27-62.

Mankiw, N. G. and D. N. Veil. 1989. Baby boom, baby bust and the housing market. Regional Science and Urban Economics. 19(2): 235-258.

McCarthy J. and R. W. Peach. 2002. Monetary policy transmission to residential investment. Economic Policy Review, Federal Reserve Bank of New York. May, 8(1): 139-158.
Meen, G. 2000. Housing cycles and efficiency. Scottish Journal of Political Economy. 47(2):114-140.
Meen, G. 2001. *Modelling spatial housing markets. Theory, Analysis and Policy.* Kluwer Academic Publishers, Boston/ Dordrecht/ London.
Meen, G. 2002. The time-series behavior of house prices: A transatlantic divide? Journal of Housing Economics. 11: 1-23.
Meen, G. and M. Andrew. 1998. Modelling regional house prices: A review of the literature. Report prepared for the Department of the Environment, Transport and the Regions. The University of Reading.
Nellis, J. G. and J. A. Longbottom. 1981. An empirical analysis of the determination of house prices in the United Kingdom. Urban Studies. 18(1): 9-21.
OECD. 2004. Housing markets, wealth and the business cycle. OECD Economic Outlook, No. 75: 157-178.
Ozane, L. and T. Thibodeau. 1983. Explaining metropolitan house price differences. Journal of Urban Economics. 13: 51-66.
Peek, J. and J. A. Wilcox. 1991. The measurement and determinants of single-family house prices. *AREUEA Journal.* 19(3): 353-382.
Pichette, L. 2000. Les effets réels du cours des actions sur la consommation. Bank of Canada. Working Paper, No. 2000-21.
Pichette, L. and D. Tremblay. 2003. Are wealth effects important in Canada? mimeograph, draft version. Bank of Canada, 43 pages.
Poterba, J. M. 1984. Tax subsidies to owner-occupied housing: An asset market approach. Quarterly Journal of Economics. 99(4): 729-752.
Poterba, J. M. 1991. House price dynamics: The role of tax policy and demographics. Brookings Paper on Economic Activity. 2: 143-199.
Pryce, G. 1999. Construction elasticities and land availability: A two-stage least-squares model of housing supply using the variable elasticity approach. Urban Studies. 36(13): 2283-2304.
Quan, D. C. and S. Titman. 1999. Do real estate prices and stock prices move together? An international analysis. Real Estate Economics. 27(2): 183-207.
CMHC. 2004. House prices, borrowing against home equity and consumer expenditures. Research Highlights, Socio-Economic Series. 04-006. January, 7 pages.
Sims, C. 1980. Macroeconomics and reality. Econometrica. 48: 1-48.
Sims, C. 1986. Are forecasting models usable for policy analysis? Federal Reserve Bank of Minneapolis Quarterly Review. 10(1): 2-16.
Smith, L. B., K. T. Rosen and G. Fallis. 1988. Recent developments in economic models of housing markets. Journal of Economic Literature. 26(1): 29-64.
Somerville, T. C. 1996. The contribution of land and structure to builder profits and house prices. Journal of Housing Research. p. 7.
Stein, J. C. 1995. Prices and trading volume in the housing market: A model with downpayment effects. The Quarterly Journal of Economics. 1102: 379-405.
Stock J. H. and M. W. Watson. 2001. Vector autoregressions. Journal of Economic Perspectives. 15(4): 101-115.
Summers, L. H. 1981. Inflation, the stock market, and owner-occupied Housing. American Economic Review. 71(2): 429-434.
Sutton, G. D. 2002. Explaining changes in house prices. BIS Quarterly Review. September 2002: 48-57.
Thiessen, G. 1995. La stabilité des prix et le marché immobilier au Canada. Bank of Canada Review. Autumn.
Tsatsaronis, K. and H. Zhu. 2004. What drives housing price dynamics: cross-country evidence. BIS Quarterly Review. March.

Wheaton, William C. 1990. Vacancy, search, and prices in a housing market matching model. Journal of Political Economy. 98: 1270-92.

APPENDIX A: STATISTICAL DATA: DESCRIPTION AND SOURCES

- **New Housing Price Indexes (house and land), 1997=100. Quarterly: 1972Q1-2003Q3.**

- Variable constructed by linking the following series.

- Source 1: New Housing Price Indexes (house and land), 1976=100, monthly, 1981M01-2003M10. Sources: CANSIM II, Table 327-005, Series Numbers: V21148160 (Canada), V21148256 (Halifax), V21148169 (Québec City), V21148172 (Montréal), V21148178 (Ottawa-Gatineau), V21148181 (Toronto), V21148184 (Hamilton), V21148211 (Winnipeg), V21148229 (Calgary), V21148232 (Edmonton), V21148238 (Vancouver).

- Source 2: New Housing Price Indexes (house and land), 1997 = 100, monthly, 1972M01-1983M12. Sources: Statistics Canada. Publication No. 62-007, January 1984, Table 11; for Canada, *Canadian Statistical Review* (11-001), various issues.

Note 1: Because of the limited number of transactions, observations for Halifax and Québec City over the period from 1981M9 to 1984M04 are not available.
Note 2: Statistics Canada started to compile New Housing Price Indexes in 1972 and even a little earlier for certain CMAs. However, for some CMAs, the series start later, namely 1975M01 for Halifax and 1976M01 for Québec City and Hamilton.
Note 3: With respect to Canada, the index is a composite aggregate of metropolitan areas with more than 10,000 inhabitants. Before 1981, the Canadian index was a composite of 22 CMAs. Linking avoids a break in the 1981 series. Statistics for Canada are not available until 1976M03. For periods prior to this date, the index was calculated as a weighted mean of the CMA indexes that were available.

- Linking Method: Linkage base year: 1981; standard linking by multiplication (a linkage factor). See Insert A.1 hereunder.

Insert A.1 Standard Linking Method

I.e.	S_new	the most recent statistical series
	S_old	the earlier series
	S_link	the linked series (the linking result)
	LF	the linkage factor defined as the annual means ratio of the recent (S_new) and earlier (S_old) series in the linkage base year
Ergo	S_link = S_new	for periods in the linking and subsequent years.
	S_link = S_old * LF	for the years prior to linking

- **Total number of housing starts (in thousands of units). Real data, seasonally unadjusted (CMAs) or seasonally adjusted (Canada). Quarterly: 1972Q1-2003Q3.**

- Source: CMHC, real data, seasonally unadjusted (CMAs) or seasonally adjusted data (Canada), monthly, 1972M01-2003M10.

Note 1: The total number of housing starts for Canada is an aggregate of housing starts in centres with 10,000 inhabitants and over.
Note 2: The data on housing starts in the various CMAs for a given period are calculated by CMA geographic boundaries in the most recent census available.

- **Employment (in thousands). Seasonally adjusted (Canada) and seasonally unadjusted (CMAs).
Quarterly: 1972Q1-2003M10 (Canada) and 1975Q2-2003Q2 (CMAs).**

- Variables constructed from the following series using a standard linking process (see Insert A.1). Linkage bases: 1976 (Canada) or 1988 (CMA).

- Canada – Source 1: CANSIM II, Table 282-0089, No. V2066967, seasonally adjusted, 1976M01-2003M10.
- Canada – Source 2: CANSIM I, No. D767608, seasonally adjusted, 1966M01-1993M12.

- CMA – Source 1: CANSIM II, Table 282-0057, No. V3473165 (Halifax), V3473168 (Québec City), V3473171 (Montréal), V3473172 (Ottawa-Gatineau), V3473175 (Toronto), V3473176 (Hamilton), V3473182 (Winnipeg), V3473185 (Calgary), V3473186 (Edmonton), V3473187 (Vancouver). 1987M01-2003M10; 3-month moving average, seasonally unadjusted.
- CMA – Source 2: CANSIM I, Matrix 2103, No. D777035 (Halifax), D777167 (Québec City), D777168 (Montréal), D777356 (Ottawa-Gatineau), D777358 (Toronto), D777359 (Hamilton), D777581 (Winnipeg), D777726 (Calgary), D777727 (Edmonton), D776892 (Vancouver). Other references: "Historical Labour Force Statistics," 71-201, 1994, pages 462-473. 1975M03-1993M12, 3-month moving average, seasonally unadjusted.

Note 1: In terms of the CMAs, the series are expressed as 3-month moving averages to overcome the large sampling variability problem. With respect to this, see the article "Quelques observations sur les régions infraprovinciales et les estimations des moyennes mobiles de 3 mois" in *La Population active* [The labour force survey?], 71-001, January 1991, pages c-2 to c-5.

Note 2: No CMA employment statistics are available prior to January 1975.

Note 3: The new and old employment series have a very highly correlated common sample (correlation in the order of 0.9998). Linking is not likely to pose a problem.

- **Consumer Price Indexes, total, 1992=100. Seasonally adjusted. Quarterly. 1972Q1-2003Q3**

- Source: CANSIM II, Table 326-001, Series: V735319 (Canada), V737227 (Halifax), V737239 (Québec City), V737245 (Montréal), V737251 (Ottawa-Gatineau), V737257 (Toronto), V737269 (Winnipeg), V737293 (Calgary), V737287 (Edmonton), V737299 (Vancouver). Monthly: 1971M01-2003M11.

Note 1: No statistical series is available for the Hamilton CMA. We are assuming that the CPI for Hamilton corresponds to that of the Toronto CMA. We used quarterly Conference Board of Canada CPI data for the Toronto and Hamilton metropolitan areas (commencing in 1987Q1) in order to verify our assumption. A 0.9995 correlation confirms the accuracy of our choice.

- **Total Retail Sales. In dollars. Seasonally adjusted (Canada) or seasonally unadjusted (CMAs). Quarterly: 1972Q1-2003Q3.**

- Variables constructed from the following series.

- Canada – Source 1: CANSIM II, Table 080-0001, No. V115584, seasonally adjusted. Monthly: 1981M01-2003M10.
- Canada – Source 2: CANSIM II, Table 080-0006, Series V1109113, seasonally adjusted. Monthly: 1972M01-1990M10
- CMAs – Source 1: CANSIM II, Table 080-0001; Series V115743 (Montréal), V115724 (Toronto), V115726 (Winnipeg), V115730 (Vancouver); seasonally unadjusted. Monthly: 1991M01-2003M10.
- CMAs – Source 2: CANSIM II, Table 080-0006; Series V111416 (Montréal), V111592 (Toronto), V111768 (Winnipeg), V112120 (Vancouver); seasonally unadjusted. Monthly: 1974M01-1989M12.
- CMAs – Source 3: Conference Board of Canada, Metropolitan Database, Series: CRTVA, CRTT, CRTM and CRTWI. Quarterly data: 1987Q1-2003Q3

Note 1: Standard linking (see Insert A.1) with 1981 as linkage base for the Canada series (sample having been enlarged). A very high common sample correlation (in the order of 0.9999) between the older series and the recent series indicates that linking is not likely to pose a problem. For the CMAs, no linking required, unitary, as no break in the series has been observed; see Note 4, however.
Note 2: For the CMAs, recent retail sales series are available only in a seasonally unadjusted form. In addition, Statistics Canada publishes retail sales statistics for only four of the ten CMAs: namely Montréal, Toronto, Winnipeg and Vancouver.
Note 3: The statistics available for the four CMAs commence in January 1974.
Note 4: Statistics Canada published no retail sales statistics on the four CMAs for the twelve months of 1990. These data were estimated on the basis of Conference Board quarterly data as follows. For each of the four CMAs, with the help of Conference Board data, we calculated the one-year growth rate over the four quarters of 1990. We made the assumption that the annual growth rate for a given quarter and a given CMA was valid for each of the months in the quarter. We applied these growth rates to the monthly data observed in 1989 (older series). We also used

Conference Board quarterly data to check for breaks in the linked series. No break was observed, so no linking was required.
Note 5: Conference Board data on retail sales in the CMAs are available quarterly for the 10 CMAs retained in our study. Unfortunately, these series do not start until 1987.

- **Average Yield on 3-month Treasury Bills (Auction average), Canada, 1972Q1-2003Q3.**

- Source: CANSIM II, Table 1760043, No. V122484. three-month Treasury Bill Monthly Return (Auctions), Canada. Monthly: 1961M01-2003M12.
- No transformation required, except [quarterly adjustment].

- **Toronto Stock Exchange Synthetic Index (TSX 300). Mean closing price during the months of each quarter. Quarterly: 1972Q1-2003Q4.**

- Source: CANSIM II, Table 1760047, No. V122620. Toronto Stock Exchange Synthetic Index (TSX 300). Month's last day closing price.

- **New Housing Price Index for area XXX, land price only. 1997=100. Quarterly: 1976Q1-2003Q4.**

- Variables constructed by standard linking process (see Insert A.1) with 1981 as linkage base.

- Canada – Source 1: CANSIM II, Table 327-005. No. V21148162. Monthly: 1981M01-2003M10.
- Canada – Source 2: Canadian Statistical Review (11-001), various issues. Monthly: 1976M01-1984M12.
- CMAs – Source 1: CANSIM II, Table 327-005. No. V21148258 (Halifax), V21148171 (Québec City), V21148174 (Montréal), V21148180 (Ottawa-Gatineau), V21148183 (Toronto), V21148186 (Hamilton), V21148213 (Winnipeg), V21148231 (Calgary), V21148234 (Edmonton), V21148240 (Vancouver). Monthly: 1981M01-2003M10.
- CMAs – Source 2: Statistics Canada. Publication No. 62-007, January 1984, Table 11. Monthly: 1976M01-1984M12.

Note 1: Because of the limited number of transactions, observations for Halifax over the 1981M9-1984M04 period are not available.

- **Construction Cost Indexes (materials and labour). 1997=100. Quarterly: 1972Q1-2003Q3. Canada and CMAs.**

- Variables constructed from a weighted average of CMA/Canada labour costs (Union Wage Rate Indexes and materials costs ([Total Construction Materials Cost Indexes, total Canada). Construction algorithm for these variables after the description of the original variables.

- Total Construction Materials Cost Index, Canada, 1981=100. Monthly: 1971M01-2003M10. Series constructed by standard linking (see Insert A.1) of two series with different bases: CZZTOTCINR and D649830. Linkage base: 1981.

  Series – Source 1: Statistics Canada, special compilation updating CANSIM I series D649830. Supplied by CMHC. CMHC code: CZZTOTCINR. 1981=100. Monthly: 1981M01-2003M10.
  Series – Source 2: Statistics Canada. Inactive series D610002 in CANSIM I. Available in publication 62-007, Statistics Canada, January 1979 and January 1985. Monthly: 1971M01-1984M12.
  Note 1: In the period common to both series (D649830 and D610002), we see a high correlation (0.984), which justifies linking even though the type of index is different.
  Note 2: No statistics at all exist on construction material costs specific to the metropolitan areas. Compilation of provincial statistics stopped in 1984M12. Similarly, there are no statistics on total construction costs in urban agglomerations; the statistics available are provincial and their production was suspended in December 1984.

- Union Wage Rate Index, 1992=100. Monthly: 1971M01-2003M10.

  Series - Source: CANSIM II, Table 327-004. No. V734362 (Canada), V734365 (Halifax), V734368 (Québec City), V734370 (Montréal), V734373 (Ottawa-Gatineau), V734374 (Toronto), V734382 (Winnipeg), V734383 (Calgary), V734384 (Edmonton), V734386 (Vancouver).

- Algorithm for constructing the construction cost indexes (materials and labour)

These indexes are a weighted mean of the [Construction Materials Cost Index] (Canada) described above and of the Union Wage Rate Index for the relevant area (CMA/Canada). The weights are those used by Statistics Canada until 1984 for calculating provincial construction cost indexes (Publication 62-007, 1979Q1 and 1985Q1). These weights varied little from one province to another and were unchanged from one period to another. The algorithm performs a correction to bring the [Construction Materials Cost Index] and the Union Wage Rate Indexes into the base year 1997=100. In the following formulas, frcm97 and frcmo97 are the linking factors. Note that frcmo97 varies by CMA.

```
series cc_hal=0.634*coutmat*(100/frcm97)+0.366*coutmo_hal*(100/frcmo97)
series cc_que=0.654*coutmat*(100/frcm97)+0.346*coutmo_QUE*(100/frcmo97)
series cc_otg=0.64*coutmat*(100/frcm97)+0.36*coutmo_OTG*(100/frcmo97)
series cc_ham=0.631*coutmat*(100/frcm97)+0.369*coutmo_HAM*(100/frcmo97)
series cc_cal=0.66*coutmat*(100/frcm97)+0.34*coutmo_CAL*(100/frcmo97)
series cc_edm=0.66*coutmat*(100/frcm97)+0.34*coutmo_EDM*(100/frcmo97)
series cc_win=0.66*coutmat*(100/frcm97)+0.34*coutmo_win*(100/frcmo97)
series cc_van=0.64*coutmat*(100/frcm97)+0.36*coutmo_van*(100/frcmo97)
series cc_mtl=0.654*coutmat*(100/frcm97)+0.346*coutmo_mtl*(100/frcmo97)
series cc_can=0.641*coutmat*(100/frcm97)+0.359*coutmo_can*(100/frcmo97)
series cc_tor=0.631*coutmat*(100/frcm97)+0.369*coutmo_tor*(100/frcmo97)
```

Note: "coutmat" = material costs and "coutmo" = labour costs

APPENDIX B: LIST OF VARIABLES BY ACRONYM

_CAL	Calgary (Census Metropolitan Area)
_CAN	Canada (National)
_EDM	Edmonton (Census Metropolitan Area)
_HAL	Halifax (Census Metropolitan Area)
_HAM	Hamilton (Census Metropolitan Area)
_MTL	Montréal (Census Metropolitan Area)
_OTG	Ottawa-Gatineau (Census Metropolitan Area)
_QUE	Québec City (Census Metropolitan Area)
_TOR	Toronto (Census Metropolitan Area)
_VAN	Vancouver (Census Metropolitan Area)
_WIN	Winnipeg (Census Metropolitan Area)

CC	Construction Cost Index (materials and labour), CMAs and Canada
EMP'T	Employment, CMAs and Canada
HS	Housing Starts, CMAs and Canada
CPI	Consumer Price Index, CMAs and Canada
NHPI	New Housing Price Index, CMAs and Canada
Y90	Real interest rate (yield rate on 90-day Treasury Bills, adjusted for last four quarters' inflation using the CPI)
LC	Land Price Index (new housing), CMAs and Canada
TSX	Toronto Stock Exchange Synthetic Index (300)
SRETAIL	Retail sales, CMAs and Canada

Note 1: Readers are asked to refer to Appendix A for a description of the variables.

Note 2: In the tables and figures, the variables' acronyms refer to their quarterly growth rate, except for Y90 and TSX which are referred to as level.

APPENDIX C: STATIONARITY TEST RESULTS

(Augmented Dickey-Fuller (ADF) Tests)

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*Prob.*	*ADF Stat.*	*Prob.*	*ADF Stat.*	*Prob.*
CC/CPI	Canada	*level*	-3.043	0.032	-3.427	0.049	0.468	0.815
		difference	-3.826	0.003	-3.799	0.018	-3.791	0.000
	Halifax	*level*	-0.823	0.811	-1.465	0.840	1.981	0.989
		difference	-3.586	0.007	-3.631	0.029	-1.688	0.087
	Québec City	*level*	-2.665	0.081	-3.162	0.094	1.185	0.940
		difference	-4.549	0.000	-4.576	0.001	-4.334	0.000
	Montréal	*level*	-2.120	0.237	-2.883	0.169	-4.822	0.000
		difference	-4.817	0.001	-4.668	0.000	-2.325	0.165
	Ottawa-Gat.	*level*	-2.325	0.165	-3.820	0.017	0.861	0.895
		difference	-5.031	0.000	-5.048	0.000	-4.408	0.000
	Toronto	*level*	-2.303	0.172	-2.616	0.273	0.381	0.794
		difference	-4.597	0.000	-4.568	0.001	-4.583	0.000
	Hamilton	*level*	-2.443	0.131	-2.468	0.344	-0.113	0.644
		difference	-5.111	0.000	-5.074	0.000	-5.132	0.000
	Winnipeg	*level*	-2.925	0.043	-3.193	0.087	-0.026	0.673
		difference	-3.420	0.011	-3.496	0.041	-3.428	0.001
	Calgary	*level*	-2.383	0.147	-2.443	0.357	0.574	0.840
		difference	-4.124	0.001	-4.105	0.007	-4.073	0.000
	Edmonton	*level*	-2.907	0.046	-2.908	0.161	0.367	0.790
		difference	-3.491	0.009	-3.478	0.043	-3.458	0.001
	Vancouver	*level*	-2.911	0.045	-2.769	0.210	0.047	0.697
		difference	-4.304	0.001	-4.559	0.001	-4.309	0.000

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*Prob.*	*ADF Stat.*	*Prob.*	*ADF Stat.*	*Prob.*
EMPLOYMENT	Canada	*level*	-0.143	0.943	-2.371	0.394	3.666	1.000
		difference	-5.708	0.000	-5.700	0.000	-4.204	0.000
	Halifax	*level*	-0.574	0.873	-2.156	0.512	2.419	0.997
		difference	-5.427	0.000	-5.418	0.000	-4.728	0.000
	Québec City	*level*	-0.662	0.853	-2.889	0.167	2.204	0.994
		difference	-5.596	0.000	-5.583	0.000	-4.932	0.000
	Montréal	*level*	0.177	0.971	-1.898	0.653	2.060	0.991
		difference	-4.542	0.000	-4.628	0.001	-4.038	0.000
	Ottawa-Gat.	*level*	0.520	0.987	-1.862	0.672	3.368	1.000
		difference	-5.843	0.000	-5.900	0.000	-3.422	0.001
	Toronto	*level*	0.002	0.957	-1.968	0.616	2.205	0.994
		difference	-3.724	0.004	-3.769	0.019	-2.951	0.003
	Hamilton	*level*	-0.757	0.829	-2.476	0.340	1.804	0.983
		difference	-5.354	0.000	-5.349	0.000	-4.983	0.000
	Winnipeg	*level*	-1.061	0.732	-3.562	0.035	1.627	0.975
		difference	-4.408	0.000	-4.360	0.003	-4.048	0.000
	Calgary	*level*	0.271	0.977	-1.082	0.929	3.268	1.000
		difference	-3.996	0.002	-4.995	0.000	-2.771	0.006
	Edmonton	*level*	-0.024	0.955	-2.539	0.309	2.638	0.998
		difference	-5.148	0.000	-5.162	0.000	-4.135	0.000
	Vancouver	*level*	0.414	0.983	-2.034	0.580	3.729	1.000
		difference	-5.956	0.000	-5.997	0.000	-4.558	0.000

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*P Value*	*ADF Stat.*	*P Value*	*ADF Stat.*	*P Value*
HS	Canada	*level*	-2.573	0.100	-2.456	0.350	-0.513	0.494
		difference	-5.859	0.000	-5.922	0.000	-5.870	0.000
	Halifax	*level*	-3.466	0.010	-3.416	0.051	-1.175	0.219
		difference	-7.379	0.000	-7.397	0.000	-7.390	0.000
	Québec City	*level*	-2.696	0.076	-2.665	0.252	-1.090	0.250
		difference	-5.957	0.000	-5.989	0.000	-5.969	0.000
	Montréal	*level*	-2.595	0.095	-2.757	0.214	-0.960	0.301
		difference	-4.948	0.000	-4.966	0.000	-4.956	0.000
	Ottawa-Gat.	*level*	-1.828	0.367	-2.019	0.588	-0.273	0.587
		difference	-5.984	0.000	-6.159	0.000	-5.988	0.000
	Toronto	*level*	-1.828	0.367	-2.019	0.588	-0.273	0.587
		difference	-5.984	0.000	-6.159	0.000	-5.988	0.000
	Hamilton	*level*	-2.856	0.052	-2.458	0.349	-2.084	0.036
		difference	-11.821	0.000	-11.939	0.000	-11.782	0.000
	Winnipeg	*level*	-2.798	0.059	-6.795	0.000	-2.122	0.033
		difference	-9.558	0.000	-9.597	0.000	-9.549	0.000
	Calgary	*level*	-2.304	0.171	-2.309	0.427	-0.693	0.416
		difference	-5.198	0.000	-5.176	0.000	-5.198	0.000
	Edmonton	*level*	-2.067	0.259	-1.951	0.625	-0.564	0.473
		difference	-5.126	0.000	-5.166	0.000	-5.121	0.000
	Vancouver	*level*	-2.789	0.061	-2.773	0.208	-0.576	0.467
		difference	-10.802	0.000	-10.797	0.000	-10.817	0.000

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*P Value*	*ADF Stat.*	*P Value*	*ADF Stat.*	*P Value*
CPI	Canada	*level*	-1.646	0.458	-0.989	0.943	1.400	0.960
		difference	-3.246	0.018	-3.534	0.037	-1.360	0.161
	Halifax	*level*	-1.527	0.519	-1.126	0.922	1.706	0.979
		difference	-3.581	0.007	-3.791	0.018	-1.654	0.093
	Québec City	*level*	-1.725	0.418	-0.879	0.956	1.440	0.963
		difference	-3.269	0.017	-4.001	0.009	-1.547	0.114
	Montréal	*level*	-1.685	0.438	-0.707	0.971	1.645	0.976
		difference	-3.570	0.007	-3.873	0.014	-1.791	0.070
	Ottawa-Gat.	*level*	-1.435	0.565	-0.906	0.953	1.798	0.983
		difference	-3.790	0.003	-3.988	0.010	-1.466	0.133
	Toronto	*level*	-1.316	0.623	-1.259	0.896	1.488	0.966
		difference	-3.212	0.020	-3.373	0.057	-1.302	0.178
	Hamilton	*level*	-1.316	0.623	-1.259	0.896	1.488	0.966
		difference	-3.212	0.020	-3.373	0.057	-1.302	0.178
	Winnipeg	*level*	-2.129	0.233	0.344	0.999	1.692	0.978
		difference	-9.915	0.000	-20.551	0.000	-1.566	0.110
	Calgary	*level*	-1.026	0.745	-1.492	0.831	2.429	0.997
		difference	-4.325	0.001	-4.383	0.003	-1.987	0.045
	Edmonton	*level*	-0.778	0.824	-1.644	0.774	2.051	0.991
		difference	-5.169	0.000	-5.185	0.000	-1.693	0.086
	Vancouver	*level*	-1.673	0.444	-1.404	0.859	1.015	0.919
		difference	-2.575	0.099	-2.921	0.157	-1.161	0.224

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*P Value*	*ADF Stat.*	*P Value*	*ADF Stat.*	*P Value*
NHPI /CPI	Canada	*level*	-3.581	0.007	-3.154	0.096	-1.772	0.073
		difference	-4.849	0.000	-5.232	0.000	-4.671	0.000
	Halifax	*level*	-4.538	0.000	-1.892	0.656	-4.318	0.000
		difference	-18.199	0.000	-19.098	0.000	-17.573	0.000
	Québec City	*level*	-3.063	0.030	-2.633	0.266	-0.083	0.655
		difference	-2.395	0.144	-2.610	0.276	-2.403	0.016
	Montréal	*level*	-3.564	0.007	-3.591	0.032	0.693	0.865
		difference	-4.642	0.000	-4.643	0.001	-4.556	0.000
	Ottawa-Gat.	*level*	-1.772	0.394	-2.857	0.178	-0.114	0.644
		difference	-4.229	0.001	-4.222	0.005	-4.234	0.000
	Toronto	*level*	-2.590	0.096	-3.382	0.055	-0.523	0.490
		difference	-3.844	0.003	-3.840	0.016	-3.848	0.000
	Hamilton	*level*	-3.169	0.023	-3.195	0.087	-0.766	0.384
		difference	-2.613	0.091	-2.804	0.197	-2.592	0.010
	Winnipeg	*level*	-1.470	0.548	-3.565	0.034	-0.399	0.540
		difference	-3.804	0.003	-3.827	0.016	-3.806	0.000
	Calgary	*level*	-2.002	0.286	-2.223	0.475	0.202	0.745
		difference	-4.916	0.000	-4.921	0.000	-4.897	0.000
	Edmonton	*level*	-1.315	0.624	-2.305	0.430	-0.023	0.675
		difference	-6.701	0.000	-6.742	0.000	-6.706	0.000
	Vancouver	*level*	-1.263	0.648	-3.685	0.025	-0.817	0.362
		difference	-7.244	0.000	-7.254	0.000	-7.234	0.000

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*P Value*	*ADF Stat.*	*P Value*	*ADF Stat.*	*P Value*
LC / CPI	Canada	*level*	-2.992	0.037	-2.627	0.269	-1.631	0.097
		difference	-6.467	0.000	-6.637	0.000	-6.340	0.000
	Halifax	*level*	-1.464	0.551	-1.695	0.752	-0.099	0.649
		difference	-18.147	0.000	-18.122	0.000	-18.173	0.000
	Québec City	*level*	-1.147	0.698	-2.029	0.583	0.417	0.803
		difference	-5.321	0.000	-5.304	0.000	-5.302	0.000
	Montréal	*level*	-1.477	0.545	-2.598	0.282	1.355	0.956
		difference	-5.617	0.000	-5.623	0.000	-5.364	0.000
	Ottawa-Gat.	*level*	-2.107	0.242	-2.899	0.164	-0.264	0.591
		difference	-4.740	0.000	-4.807	0.001	-4.747	0.000
	Toronto	*level*	-2.759	0.065	-2.996	0.135	-0.587	0.463
		difference	-3.759	0.004	-3.769	0.019	-3.762	0.000
	Hamilton	*level*	-3.424	0.011	-2.656	0.256	-3.665	0.000
		difference	-9.128	0.000	-18.318	0.000	-8.706	0.000
	Winnipeg	*level*	-2.358	0.155	-3.930	0.012	-0.227	0.604
		difference	-9.826	0.000	-9.927	0.000	-9.839	0.000
	Calgary	*level*	-2.357	0.155	-2.353	0.404	0.801	0.885
		difference	-5.570	0.000	-5.616	0.000	-5.458	0.000
	Edmonton	*level*	-2.728	0.070	-3.452	0.046	-0.307	0.575
		difference	-3.583	0.007	-3.620	0.029	-3.588	0.000
	Vancouver	*level*	-1.821	0.370	-2.990	0.136	-0.707	0.410
		difference	-7.361	0.000	-7.359	0.000	-7.363	0.000

Variable	Area		With constant		With constant & trend		Without constant or trend	
			ADF Stat.	*P Value*	*ADF Stat.*	*P Value*	*ADF Stat.*	*P Value*
Y90	Canada	*level*	-1.959	0.305	-2.697	0.239	-0.830	0.356
		difference	-6.196	0.000	-6.310	0.000	-6.204	0.000
TSX	Canada	*level*	-19.545	0.000	-19.636	0.000	-19.519	0.000
		difference	-9.605	0.000	-9.592	0.000	-9.618	0.000
SRETAIL / CPI	Canada	*level*	-0.370	0.911	-2.442	0.357	1.873	0.986
		difference	-4.716	0.000	-4.731	0.001	-4.273	0.000
	Montréal	*level*	0.357	0.981	-1.531	0.817	1.938	0.988
		difference	-4.265	0.001	-4.391	0.003	-3.803	0.000
	Toronto	*level*	-0.199	0.936	-2.281	0.443	1.853	0.985
		difference	-3.814	0.003	-3.846	0.015	-3.264	0.001
	Winnipeg	*level*	0.023	0.959	-1.337	0.877	1.824	0.984
		difference	-3.272	0.017	-3.372	0.057	-2.963	0.003
	Vancouver	*level*	-0.738	0.834	-2.876	0.172	1.331	0.954
		difference	-3.389	0.012	-3.363	0.058	-2.990	0.003

APPENDIX D COMPLEMENTARY RESULTS TABLES

Table D.1

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% NHPI SHOCK (CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.07	1.14	1.37	1.45	1.73	1.58	1.29	1.72	1.66	1.83	1.66	1.84
3	0.97	1.48	1.66	1.5	2.27	1.8	1.39	2.06	1.96	2.14	1.95	2.27
4	1.16	1.66	2	1.61	2.62	2.27	1.55	2.37	2.13	2.34	2.2	2.61
5	1.09	2.07	2.17	1.84	2.79	2.62	1.64	2.45	2.41	2.25	2.34	2.74
6	1.09	2.31	2.26	2.01	2.94	2.89	1.66	2.42	2.49	2.02	2.39	2.64
7	1.12	2.57	2.4	2.07	3.05	3.15	1.77	2.44	2.44	1.79	2.41	2.62
8	1.11	2.78	2.49	2.15	3.12	3.33	1.9	2.47	2.51	1.53	2.43	2.64
9	1.09	2.91	2.5	2.2	3.15	3.5	1.94	2.5	2.57	1.29	2.41	2.59
10	1.08	3.04	2.56	2.23	3.12	3.69	1.95	2.49	2.53	1.11	2.38	2.51
11	1.07	3.19	2.59	2.23	3.1	3.83	1.94	2.39	2.47	0.96	2.35	2.44
12	1.05	3.32	2.59	2.26	3.06	3.94	1.94	2.23	2.45	0.84	2.32	2.33
13	1.04	3.44	2.61	2.29	3.01	4.04	1.94	2.08	2.42	0.77	2.28	2.21
14	1.04	3.54	2.61	2.29	2.95	4.13	1.94	1.95	2.36	0.74	2.25	2.14
15	1.02	3.64	2.61	2.29	2.88	4.21	1.94	1.85	2.31	0.74	2.22	2.09
16	1.02	3.73	2.61	2.29	2.81	4.27	1.94	1.77	2.29	0.75	2.19	2.04
17	1.01	3.8	2.61	2.3	2.74	4.33	1.93	1.73	2.26	0.77	2.17	2.01
18	1	3.88	2.6	2.3	2.68	4.37	1.92	1.7	2.23	0.79	2.14	2
19	0.99	3.95	2.6	2.3	2.63	4.42	1.9	1.67	2.21	0.81	2.12	1.99
20	0.98	4.01	2.6	2.3	2.59	4.45	1.89	1.65	2.2	0.83	2.1	2

Table D.2

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% HS SHOCK
(CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	0.00	0.00	0.01	0.01	0.02	0.01	0.00	0.01	0.02	0.04	0.01	0.02
2	-0.01	0.00	0.02	0.02	0.03	0.01	0.01	0.02	0.03	0.06	0.01	0.04
3	0.00	0.01	0.04	0.02	0.04	0.02	0.01	0.04	0.05	0.08	0.02	0.05
4	0.00	0.01	0.05	0.03	0.05	0.03	0.02	0.06	0.07	0.09	0.03	0.06
5	0.00	0.01	0.05	0.04	0.05	0.04	0.02	0.07	0.07	0.11	0.03	0.07
6	0.00	0.01	0.06	0.04	0.06	0.04	0.02	0.06	0.07	0.11	0.03	0.06
7	0.00	0.02	0.06	0.04	0.06	0.04	0.02	0.06	0.07	0.1	0.03	0.07
8	0.00	0.02	0.06	0.05	0.06	0.05	0.03	0.05	0.06	0.09	0.03	0.07
9	0.00	0.02	0.06	0.05	0.07	0.05	0.03	0.05	0.06	0.08	0.03	0.07
10	0.00	0.02	0.07	0.05	0.07	0.05	0.03	0.05	0.06	0.07	0.03	0.07
11	0.00	0.03	0.07	0.05	0.07	0.05	0.03	0.05	0.06	0.06	0.03	0.08
12	0.00	0.03	0.07	0.05	0.07	0.06	0.03	0.05	0.06	0.06	0.03	0.08
13	0.00	0.03	0.07	0.05	0.07	0.06	0.03	0.05	0.06	0.05	0.03	0.08
14	0.00	0.03	0.07	0.05	0.06	0.06	0.03	0.05	0.05	0.05	0.03	0.08
15	0.00	0.03	0.07	0.05	0.06	0.06	0.03	0.05	0.05	0.05	0.03	0.08
16	0.00	0.03	0.07	0.05	0.06	0.06	0.03	0.05	0.05	0.05	0.03	0.08
17	0.00	0.03	0.07	0.05	0.06	0.07	0.03	0.05	0.05	0.05	0.03	0.08
18	0.00	0.03	0.07	0.05	0.06	0.07	0.03	0.05	0.05	0.05	0.03	0.09
19	0.00	0.03	0.07	0.05	0.06	0.07	0.03	0.05	0.05	0.05	0.03	0.09
20	0.00	0.03	0.07	0.05	0.06	0.07	0.03	0.05	0.05	0.05	0.03	0.09

Table D.3

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% EMPLOYMENT SHOCK (CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	-0.04	-0.05	0.25	0.10	0.24	0.11	-0.07	0.04	0.01	0.09	0.04	0.34
2	0.02	-0.05	0.29	0.16	0.37	0.11	-0.13	0.17	0.07	0.25	0.1	1.1
3	-0.01	-0.02	0.34	0.21	0.29	0.15	-0.16	0.21	0.19	0.56	0.17	1.41
4	0.02	0	0.48	0.21	0.46	0.18	-0.16	0.35	0.25	0.88	0.26	1.09
5	0.09	-0.07	0.5	0.27	0.79	0.19	-0.05	0.45	0.24	1.15	0.33	1.14
6	0.13	-0.07	0.47	0.31	1	0.24	-0.01	0.51	0.26	1.28	0.36	1.29
7	0.17	-0.06	0.49	0.32	1.1	0.27	-0.06	0.57	0.26	1.17	0.37	1.23
8	0.19	-0.05	0.5	0.34	1.22	0.27	-0.08	0.6	0.23	0.87	0.37	1.26
9	0.17	-0.03	0.5	0.39	1.32	0.3	-0.04	0.57	0.21	0.59	0.36	1.18
10	0.17	-0.01	0.51	0.42	1.31	0.33	-0.02	0.52	0.19	0.4	0.35	0.77
11	0.17	0.01	0.53	0.42	1.3	0.34	0.01	0.48	0.16	0.25	0.33	0.31
12	0.17	0.02	0.53	0.45	1.31	0.36	0.05	0.44	0.13	0.15	0.32	-0.09
13	0.18	0.03	0.53	0.46	1.3	0.38	0.09	0.4	0.09	0.08	0.31	-0.54
14	0.19	0.04	0.53	0.46	1.26	0.4	0.11	0.36	0.07	0.05	0.29	-0.95
15	0.19	0.06	0.52	0.47	1.24	0.42	0.12	0.32	0.05	0.02	0.28	-1.26
16	0.19	0.07	0.52	0.48	1.23	0.43	0.15	0.29	0.03	0.01	0.27	-1.55
17	0.19	0.08	0.51	0.48	1.2	0.44	0.17	0.27	0.01	0	0.26	-1.8
18	0.19	0.1	0.51	0.48	1.18	0.46	0.2	0.25	0	0.01	0.25	-1.97
19	0.19	0.11	0.51	0.49	1.16	0.47	0.22	0.24	-0.01	0.02	0.24	-2.07
20	0.20	0.12	0.51	0.49	1.15	0.48	0.24	0.23	-0.02	0.03	0.23	-2.12

Table D.4

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% Y90 SHOCK
(CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	-0.10	-0.07	-0.02	0.09	0.20	-0.15	0.07	0.30	0.00	0.10	0.06	0.09
2	-0.09	-0.21	-0.12	0.07	0.15	-0.35	0.05	0.38	-0.02	-0.73	-0.04	-0.16
3	0.00	-0.25	-0.18	0.16	0.07	-0.53	0.03	0.31	-0.09	-1.21	-0.1	-0.47
4	-0.02	-0.38	-0.32	0.04	-0.42	-0.85	-0.1	0.02	-0.45	-1.19	-0.28	-0.91
5	-0.04	-0.57	-0.46	-0.02	-0.68	-1.04	-0.16	-0.26	-0.67	-1.27	-0.42	-1.34
6	0.04	-0.64	-0.52	0.01	-0.83	-1.19	-0.13	-0.43	-0.78	-1.24	-0.46	-1.58
7	0.06	-0.7	-0.62	0.09	-0.95	-1.32	-0.11	-0.53	-0.84	-1.11	-0.5	-1.78
8	0.06	-0.78	-0.68	0.15	-0.98	-1.39	-0.06	-0.6	-0.95	-1.03	-0.54	-1.98
9	0.08	-0.81	-0.7	0.18	-1.02	-1.47	-0.01	-0.7	-1.01	-1.03	-0.57	-2.15
10	0.08	-0.83	-0.72	0.22	-1.03	-1.53	0.01	-0.85	-1.04	-1.1	-0.6	-2.31
11	0.08	-0.88	-0.76	0.24	-1.04	-1.56	0.02	-1.04	-1.14	-1.18	-0.63	-2.49
12	0.08	-0.92	-0.78	0.27	-1.03	-1.59	0.04	-1.2	-1.24	-1.17	-0.67	-2.62
13	0.09	-0.93	-0.8	0.29	-0.97	-1.6	0.08	-1.32	-1.29	-1.1	-0.69	-2.72
14	0.10	-0.96	-0.82	0.32	-0.9	-1.6	0.11	-1.41	-1.32	-1.04	-0.71	-2.79
15	0.11	-0.99	-0.84	0.33	-0.81	-1.58	0.14	-1.45	-1.36	-0.98	-0.73	-2.83
16	0.12	-1.01	-0.85	0.33	-0.69	-1.55	0.17	-1.47	-1.39	-0.91	-0.74	-2.85
17	0.12	-1.04	-0.86	0.33	-0.56	-1.51	0.19	-1.47	-1.39	-0.85	-0.76	-2.86
18	0.13	-1.06	-0.87	0.34	-0.42	-1.46	0.21	-1.48	-1.4	-0.81	-0.77	-2.85
19	0.13	-1.08	-0.88	0.34	-0.29	-1.41	0.23	-1.47	-1.41	-0.77	-0.77	-2.82
20	0.14	-1.1	-0.88	0.34	-0.15	-1.36	0.25	-1.47	-1.41	-0.72	-0.78	-2.79

Table D.5

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% CPI SHOCK
(CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	-0.96	-0.85	-0.63	-0.67	-0.03	-0.50	-0.87	-1.08	-0.87	-0.37	-0.78	-0.70
2	-1.24	-1.14	-0.75	-0.73	0.39	0.05	-0.81	-1.11	-0.88	0.49	-0.78	-0.97
3	-1.74	-1.35	-0.74	-0.8	0.74	0.6	-0.67	-1.04	-0.89	1.4	-0.72	-1.05
4	-1.83	-1.51	-0.74	-0.67	1.21	0.77	-0.75	-1.22	-1.1	0.99	-0.77	-1.09
5	-1.87	-1.62	-0.64	-0.29	1.26	0.98	-0.72	-1.28	-1.39	0.24	-0.84	-1.29
6	-1.99	-1.66	-0.53	-0.04	1.15	1.14	-0.67	-1.54	-1.54	-0.67	-0.96	-1.73
7	-2.02	-1.55	-0.41	0.17	1.11	1.21	-0.75	-1.83	-1.72	-1.68	-1.07	-2.19
8	-2.17	-1.53	-0.39	0.18	0.52	1.2	-0.94	-2.32	-2.21	-2.81	-1.32	-2.7
9	-2.27	-1.58	-0.4	0.18	-0.14	1.18	-1.14	-2.83	-2.56	-3.71	-1.6	-3.31
10	-2.30	-1.55	-0.33	0.27	-0.86	1.06	-1.23	-3.13	-2.76	-4.26	-1.79	-3.79
11	-2.36	-1.49	-0.32	0.42	-1.59	0.93	-1.32	-3.39	-2.98	-4.56	-1.97	-4.18
12	-2.37	-1.46	-0.34	0.48	-2.23	0.87	-1.36	-3.56	-3.21	-4.73	-2.17	-4.57
13	-2.38	-1.41	-0.32	0.52	-2.88	0.74	-1.38	-3.67	-3.34	-4.81	-2.35	-4.88
14	-2.40	-1.33	-0.3	0.59	-3.41	0.58	-1.44	-3.79	-3.41	-4.84	-2.51	-5.09
15	-2.44	-1.27	-0.32	0.64	-3.91	0.44	-1.5	-3.91	-3.53	-4.83	-2.67	-5.26
16	-2.47	-1.21	-0.32	0.67	-4.37	0.3	-1.56	-4	-3.63	-4.77	-2.83	-5.38
17	-2.50	-1.14	-0.32	0.72	-4.74	0.16	-1.6	-4.07	-3.68	-4.71	-2.97	-5.43
18	-2.52	-1.06	-0.32	0.77	-5.07	0.02	-1.64	-4.12	-3.72	-4.66	-3.1	-5.45
19	-2.53	-0.99	-0.33	0.81	-5.33	-0.12	-1.66	-4.12	-3.77	-4.62	-3.23	-5.45
20	-2.53	-0.91	-0.33	0.83	-5.53	-0.25	-1.67	-4.11	-3.79	-4.58	-3.35	-5.42

Table D.6

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% CC SHOCK
(CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	-0.05	0.02	0.04	-0.02	0.14	0.11	0.19	0.01	0.08	-0.40	0.06	0.24
2	-0.22	0.08	0.06	-0.02	0	0.01	0.29	-0.06	0.08	-0.83	0.06	0.28
3	-0.26	0.07	0.15	0.04	0.04	0.05	0.37	-0.23	0.06	-1.01	0.08	0.36
4	-0.24	0.05	0.14	0.11	0.03	0.11	0.4	-0.26	0.02	-1.14	0.1	0.4
5	-0.20	0.12	0.23	0.17	-0.13	-0.01	0.54	-0.22	0.02	-1.45	0.1	0.31
6	-0.15	0.13	0.27	0.22	-0.09	-0.02	0.55	-0.33	-0.03	-1.74	0.1	0.21
7	-0.18	0.13	0.26	0.22	-0.07	-0.03	0.53	-0.47	-0.13	-1.85	0.08	0.14
8	-0.23	0.18	0.27	0.25	-0.09	-0.1	0.51	-0.6	-0.18	-1.93	0.05	0.07
9	-0.22	0.23	0.29	0.27	-0.08	-0.11	0.5	-0.71	-0.2	-1.92	0.02	0.03
10	-0.24	0.27	0.29	0.27	-0.07	-0.09	0.49	-0.74	-0.24	-1.8	-0.01	0.01
11	-0.25	0.29	0.29	0.29	-0.08	-0.13	0.49	-0.76	-0.27	-1.66	-0.05	-0.03
12	-0.23	0.31	0.3	0.3	-0.12	-0.15	0.5	-0.76	-0.29	-1.51	-0.1	-0.08
13	-0.24	0.34	0.3	0.3	-0.15	-0.16	0.5	-0.76	-0.31	-1.38	-0.15	-0.11
14	-0.24	0.36	0.3	0.31	-0.17	-0.19	0.49	-0.77	-0.34	-1.29	-0.19	-0.13
15	-0.25	0.39	0.3	0.32	-0.2	-0.21	0.48	-0.78	-0.37	-1.22	-0.23	-0.16
16	-0.26	0.42	0.3	0.32	-0.22	-0.23	0.46	-0.81	-0.38	-1.16	-0.28	-0.17
17	-0.27	0.45	0.3	0.32	-0.23	-0.25	0.46	-0.83	-0.39	-1.13	-0.31	-0.18
18	-0.27	0.47	0.3	0.32	-0.24	-0.26	0.45	-0.84	-0.41	-1.11	-0.35	-0.19
19	-0.27	0.5	0.3	0.33	-0.25	-0.28	0.45	-0.84	-0.41	-1.09	-0.39	-0.2
20	-0.27	0.52	0.29	0.33	-0.26	-0.29	0.44	-0.83	-0.42	-1.09	-0.42	-0.21

Table D.7

CUMULATIVE NHPI IMPULSE RESPONSE TO A 1% LC SHOCK (CMA, Panel and Canada – Seven-variable VAR Model with LC)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	0.46	0.25	0.26	0.49	0.54	0.41	0.28	0.53	0.46	0.67	0.50	0.51
2	0.53	0.29	0.4	0.84	0.87	0.57	0.27	1.03	0.87	1.2	0.85	0.95
3	0.52	0.33	0.65	0.86	1.15	0.38	0.16	1.35	1.01	1.4	0.97	1.2
4	0.62	0.28	0.74	1.02	1.41	0.27	0.2	1.64	1.19	1.46	1.03	1.42
5	0.57	0.29	0.81	1.19	1.57	0.19	0.16	1.75	1.45	1.31	1.03	1.56
6	0.53	0.24	0.88	1.31	1.67	0.12	0.2	1.8	1.66	1.13	1	1.51
7	0.49	0.24	0.92	1.36	1.72	0.11	0.25	1.89	1.77	0.92	0.97	1.35
8	0.43	0.23	0.93	1.42	1.72	0.12	0.25	1.95	1.86	0.59	0.94	1.18
9	0.43	0.25	0.91	1.54	1.7	0.13	0.24	2.02	1.99	0.31	0.9	1
10	0.41	0.28	0.91	1.6	1.66	0.11	0.23	2.07	2.03	0.14	0.85	0.81
11	0.39	0.31	0.9	1.64	1.6	0.1	0.25	2.04	2.02	0.07	0.82	0.65
12	0.38	0.33	0.89	1.67	1.56	0.09	0.28	1.97	2.01	0.11	0.78	0.51
13	0.35	0.37	0.89	1.71	1.53	0.08	0.3	1.89	2.01	0.17	0.75	0.36
14	0.34	0.4	0.89	1.74	1.5	0.09	0.31	1.8	1.99	0.25	0.72	0.23
15	0.33	0.43	0.88	1.75	1.48	0.1	0.32	1.73	1.95	0.36	0.7	0.13
16	0.30	0.46	0.89	1.78	1.47	0.11	0.33	1.67	1.91	0.47	0.68	0.06
17	0.29	0.5	0.89	1.79	1.47	0.11	0.33	1.63	1.87	0.55	0.66	0.02
18	0.27	0.53	0.89	1.8	1.48	0.11	0.33	1.59	1.82	0.59	0.64	0.02
19	0.25	0.56	0.9	1.81	1.5	0.11	0.33	1.57	1.75	0.58	0.62	0.05
20	0.24	0.6	0.9	1.82	1.54	0.12	0.33	1.55	1.7	0.56	0.61	0.1

Table D.8

CUMULATIVE NHPI IMPULSE RESPONSE TO A TSX SHOCK
(CMA, Panel and Canada – Reference Model)

Horizon	HAL	QUE	MTL	OTG	TOR	HAM	WIN	CAL	EDM	VAN	PANEL	CANADA
1	0.01	0.01	0.01	0.00	0.01	0.01	-0.01	-0.01	0.01	0.06	0.01	0.02
2	0.01	0.03	0.04	0.03	0.06	0.01	-0.02	0	0.04	0.15	0.03	0.07
3	-0.01	0.02	0.07	0.11	0.09	0.02	-0.01	0.05	0.07	0.2	0.06	0.11
4	-0.02	0.02	0.1	0.17	0.12	0.04	0	0.06	0.07	0.27	0.07	0.15
5	-0.03	0.01	0.11	0.21	0.14	0.05	0.01	0.09	0.08	0.29	0.08	0.15
6	-0.04	0	0.12	0.23	0.16	0.07	0.01	0.12	0.08	0.29	0.09	0.16
7	-0.05	-0.02	0.12	0.24	0.18	0.08	0.01	0.13	0.07	0.29	0.09	0.15
8	-0.05	-0.03	0.11	0.26	0.21	0.1	0	0.14	0.06	0.26	0.08	0.15
9	-0.06	-0.04	0.11	0.27	0.23	0.11	-0.01	0.14	0.04	0.21	0.08	0.15
10	-0.06	-0.04	0.1	0.27	0.25	0.12	-0.01	0.14	0.03	0.15	0.07	0.15
11	-0.07	-0.04	0.1	0.28	0.26	0.13	-0.01	0.14	0.01	0.09	0.07	0.14
12	-0.07	-0.04	0.1	0.28	0.26	0.14	-0,01	0.11	-0.01	0.03	0.06	0.13
13	-0.08	-0.03	0.1	0.28	0.26	0.15	-0.01	0.09	-0.02	-0.01	0.06	0.11
14	-0.08	-0.03	0.11	0.28	0.24	0.15	-0.01	0.07	-0.04	-0.05	0.05	0.09
15	-0.08	-0.02	0.11	0.28	0.22	0.15	-0.02	0.04	-0.06	-0.07	0.05	0.07
16	-0.08	-0.01	0.1	0.28	0.2	0.15	-0.02	0.02	-0.07	-0.08	0.05	0.06
17	-0.07	0	0.1	0.28	0.18	0.14	-0.02	0	-0.08	-0.08	0.05	0.05
18	-0.07	0.01	0.1	0.28	0.16	0.14	-0.02	-0.01	-0.09	-0.07	0.05	0.04
19	-0.07	0.01	0.1	0.28	0.14	0.13	-0.02	-0.02	-0.1	-0.06	0.05	0.04
20	-0.07	0.02	0.1	0.28	0.12	0.13	-0.02	-0.03	-0.1	-0.05	0.05	0.04