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Industry Restructuring, Mark-ups, and Exchange Rate Pass-Through

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Abstract

Consumer prices are not very responsive to movements in nominal exchange rates and their response has fallen in Canada since the mid 1980s. This paper explores two of the most likely explanations for this decline in exchange rate pass-through to consumer prices: (1) lower inflation and (2) restructuring in the retail sector. We believe that both explanations are important but our primary focus in this paper is on the second explanation. We discuss the restructuring that has occurred in Canadian retail and trends in mark-ups and concentration in that sector. We argue that to understand these trends, it is important to examine pass-through in industrial organization models with strategic elements. Finally, we present a series of such models and evaluate the effects of various forms of restructuring on mark-ups, concentration, and exchange rate pass-through.

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1 Introduction

It has been extensively documented that consumer prices are not very responsive to movements in nominal exchange rates. Recently, it has also been argued that these prices have become considerably less responsive in Canada since the mid 1980s. This paper explores two of the most likely explanations for the apparent fall in the response of consumer prices to exchange rate fluctuations: (1) lower inflation and (2) restructuring in the retail sector, with particular focus on the second explanation.

It is important to gain insight into the connections between nominal exchange rate movements and consumer prices as this relationship has implications for both monetary and exchange rate policy. If the relationship is weak, the expenditure-shifting effects of monetary shocks are diminished. Indeed, the arguments made by Friedman (1952) and Feldstein (1997) for flexible exchange rates rely extensively on nominal exchange rate movements being passed through to consumer prices. If consumer prices are unresponsive, relative price adjustments will not occur and exchange rates may not act as automatic stabilizers.

Furthermore, a better understanding of this association may provide important insights into the factors that influence price determination. This endeavor may allow us to quantify the relative importance of macroeconomic factors such as monetary and fiscal policy and inflation and microeconomic factors such as market structure on the price-setting behaviour of firms.

It is especially important to understand why the relationship may have changed. A particularly interesting question is whether or not monetary policy influences the degree to which prices respond to exchange rate movements (that is, the degree of exchange rate pass-through). Taylor (2001), for example, argues that lower pass-through of costs to prices should not be taken as exogenous to the inflationary environment. Furthermore, a number of researchers have presented both time series and cross- country evidence of a positive relationship between inflation and exchange rate pass-through (for example, Devereux and Yetman (2003) and Choudhri and Hakura (2006)). This evidence has led some to speculate that the shift in monetary policy in Canada in the early 1990s toward lower inflation may have contributed to lower exchange rate pass-through.

We discuss two theoretical approaches in the literature which are capable of generating a positive relationship between inflation and exchange rate pass-through. One approach relies on nominal rigidities and argues that inflation influences *firms'* decisions as to the degree to which their prices should respond to movements in the exchange rate. Another approach focuses on consumer search and argues that inflation influences *consumers'* decisions to search

over prices, which, in turn, affects the market power of firms and, therefore, their ability to pass-through exchange rate movements into their prices.

We then consider the hypothesis that changes in the retail sector in Canada that began in the late 1980s may have contributed to the fall in exchange rate pass-through to retail prices. We discuss the forces that have led to restructuring in that industry and examine trends in industry concentration and mark-ups over the last twenty years. This approach to explaining the fall in pass-through implicitly assumes that prices are determined in an environment in which firms interact strategically. With this in mind, we analyze a series of industrial organization models of price setting and evaluate the effects of various forms of restructuring on pass-through in those models.

A strategic approach to examine the relationship between exchange rates and prices has firm foundations in the microeconomic literature on pass-through which was developed beginning in the late 1980s. A recent survey by Amirault, Kwan and Wilkinson (2005) of the price-setting behaviour of Canadian firms provides empirical motivation for a strategic approach to price setting. Their results suggest, for example, that the number of competitors in an industry is a very important determinant of the frequency of price adjustments. Furthermore, firms that reported that the frequency of their price changes had increased over the past decade indicated that the most important factor generating this increase was increased competition.

A focus on strategic considerations to explore the forces that may have caused the decline in pass-through in Canada stands in contrast to many of the more recent macroeconomic models of exchange rate pass-through with nominal rigidities. Those models typically assume a market structure and a form for consumer preferences such that firms do not interact strategically, but instead price at a constant mark-up over marginal cost (or over expected marginal cost). This approach implicitly focuses attention on the link between inflation and pass-through as mark-up fluctuations *must* be associated with nominal rigidities in this framework.

We conclude that both lower inflation and restructuring in the retail sector are important for explaining observed lower pass-through of exchange rates to consumer prices in Canada. These factors should be seen as complementary and may have reinforced one another in lowering pass-through.

The remainder of the paper is organized as follows. Section 2 discusses the evidence on declining pass-through and the relationship between pass- through and inflation. Section 3 highlights the relationship between mark-up responses and price responses to exchange rate movements and clarifies the underlying factors which determine the magnitude of pass-

through. Section 4 describes theoretical research aimed at addressing the positive relationship between inflation and pass-through. Section 5 discusses trends in Canadian retailing. Section 6 briefly discusses industrial organization approaches to examining pass-through. Sections 7 and 8 present a series of such models and analyzes the ability of different forms of restructuring to generate the retailing trends discussed in Section 5. Section 9 concludes.

2 Exchange Rate Pass-Through Evidence

2.1 Pass-Through Estimation

The standard definition of exchange rate pass-through is the percentage change in local currency *import prices* resulting from a one percent change in the exchange rate between the exporting and importing countries. Goldberg and Knetter (1997) discuss the general approaches in the literature to measuring this form of exchange rate pass-through. As they explain, researchers typically perform a regression analysis of the following form to estimate pass-through:

$$p_t = \alpha + \delta X_t + \gamma E_t + \psi Z_t + \epsilon_t \tag{1}$$

where p is the local currency import price, X is a measure of exporter's cost, Z may include import demand shifters, and E is the exchange rate. The coefficient γ is the pass-through coefficient and pass-through is complete if $\gamma = 1$ and incomplete if $\gamma < 1$. Their paper provides a good survey of empirical studies which have estimated these coefficients at the aggregate level and at the industry level. They conclude that most studies focused on the U.S. and estimated the pass-through coefficient to be around 60% for that country.

Several authors have estimated exchange rate pass-through to import prices for a variety of countries and industries since Goldberg and Knetter wrote their survey article. Campa and Goldberg (2004) provide estimates for the OECD countries using quarterly data from 1975 to 1999. They estimate average pass-through to import prices across the countries in their sample to be .61 in the short-run and .77 in the long-run (one year). For Canada, their estimates are quite close to the average: .65 and .68 respectively. They also provide estimates for sub-aggregates of import prices (food, energy, raw materials, manufacturing products, and non-manufacturing products) and find that most industries exhibit only partial pass-through in the short-run.

Kardasz and Stollery (2001) provide pass-through estimates to prices of both imports and domestically produced goods using data from 1972-1989 for thirty-three Canadian manufacturing industries. Their estimate of the average exchange rate pass-through elasticity is

.13 for domestic goods and .26 for imported goods and they found substantial variation is pass-through across the industries in their sample.

More recently, researchers have also become interested in measuring and understanding the percentage change in local currency *consumer or retail prices* (which includes both imported and domestic goods) resulting from a one percent change in the exchange rate. The increased attention on pass-through to consumer prices has been partially fueled by theoretical models which examine pass-through and real exchange rate behaviour in environments where exporting firms set consumer prices in local currencies. The simplest versions of these models assume that prices are set prior to the realization of the nominal exchange rate and predict zero pass-through to consumer prices. The prevalence of these models and their stark predictions have made it increasingly important to gain a better understanding of the behaviour of exchange rate pass-through to consumer prices.

Estimates of pass-through to consumer prices has typically been estimated to be significantly lower than to import prices. Duguay (1994) and Leung (2003) provide estimates for Canada and found that the long-run exchange rate elasticity to the aggregate consumer price index and to the consumer price index excluding food and energy were around 20% prior to the mid 1980s. [1]

2.2 Changes in Exchange Rate Pass-Through

Recently, many economists have speculated that pass-through of exchange rates to both import prices and consumer prices have been declining. Campa and Goldberg (2004) use two types structural break tests on their import price regressions and conclude that there has been a tendency toward declines in pass-through, but the decline was significant in only a small number of cases. Otani, Shiratsuka, and Shirota (2003) provide evidence of a fall in exchange rate pass-through to the price of imports in Japan for a large set of goods. McCarthy (2000) also finds evidence of lower levels of pass-through to import prices for a set of nine OECD countries during the period from 1983-1998 than during 1976-1982. Gagnon and Ihrig (2001), using data from 1971-2000 for twenty countries, also conclude that pass-through to consumer prices has fallen since the 1980s. Frankel, Parsley, and Wei (2005) find a downward trend in pass-through to imported goods prices and the CPI using a set of seventy-six countries.

Researchers focused on the Canadian experience have argued that pass-through to con-

[1] Note, however, that these estimates are not much lower than those found by Kardasz and Stollery (2001) using Canadian import prices in manufacturing.

sumer prices in Canada has fallen during the last ten to fifteen years. Indeed, the Bank of Canada Monetary Report (2000) argues that pass-through to core CPI has fallen in Canada since the mid-1980s even though the import content in core CPI has risen. This argument is based partially on a discussion of the Canadian experience presented in Lafléche (1996-1997). Leung (2003) performs structural break tests on exchange rate pass-through regressions and finds evidence of breaks in the mid 1980s. He also finds that both short and long run pass-through elasticities are statistically insignificant when estimated using consumer price data from the mid 1980s to 2002.

2.3 Inflation and Exchange Rate Pass-Through

These declines in exchange rate pass-through coincided with a time period in which average inflation rates in the developed world also fell. These two trends have led some researchers to speculate that lower inflation is related to lower pass-through and further, may *cause* pass-through to decline (see the Bank of Canada Monetary Report (2000)). In the next section, we discuss theoretical models which address this relationship but here we briefly discuss empirical evidence of a positive relationship between inflation and pass-through.

Campa and Goldberg (2004) use cross-country regressions to address this issue and show that country-specific rates of pass-through to import prices are not significantly related to inflation or money growth in their sample. However, Devereux and Yetman (2003) use a similar approach with a sample of 120 countries and conclude that both the level and volatility of inflation are positively related to exchange rate pass-through to the consumer price index. Choudhri and Hakura (2006) find a similar result for consumer prices for the period from 1979-2000 in a set of seventy-one countries. Gagnon and Ihrig (2001) also find a positive relationship between the stability of inflation and pass-through to the CPI, however, they find much weaker evidence of a link between monetary policy and pass-through. Frankel, Parsley, and Wei (2005) argue that only part of the downward trend in pass-through can be explained by changes in monetary factors, including inflation.

3 Exchange Rate Pass-Through Preliminaries

Below, we use the basic definition of the mark-up of price over marginal cost to derive relationships between cost fluctuations, mark-up fluctuations, and pass-through shifts. This approach allows us to provide insights into the possible forces that may have contributed to the decline in exchange rate pass-through to consumer prices in Canada.

3.1 Mark-ups and Pass-Through

Consider the following model of a retail industry. Suppose there are n retailers who produce final goods for sale in the domestic market using constant-returns-to-scale technologies. The goods that they sell could be homogeneous or differentiated. Retailers use two types of inputs: domestic inputs which are priced in domestic currency and imported inputs which are priced in foreign currency. Retailers are price takers in all input markets. Associated with the technologies used by retailers are unit cost functions denominated in domestic currency. This cost function is a function of the price of domestic inputs, w (expressed in domestic currency), the price of imported inputs, w^F (expressed in foreign currency), and the spot exchange rate, s (domestic currency per unit of foreign currency). We denote this function for retailer j as follows:

$$c_j(s, w, w^F).$$

The mark-up is defined as the ratio of price to unit cost. We denote the mark-up for retailer j by m_j and by definition have the following basic relationship:

$$p_j = m_j c_j(s, w, w^F), \tag{2}$$

where p_j is the domestic currency price of the final good sold by retailer j. Now, in general, the mark-up can depend upon a number of variables including the properties of the demand function, the number of retailers, the market structure, own costs, rivals' costs, etc. Clearly, if the mark-up depends on costs, then changes in the exchange rate which affect costs will also affect mark-ups.

Logging and differentiating equation (**??**) with respect to the log of the exchange rate gives our measure of exchange rate pass-through to the price of retailer j:

$$\frac{\partial ln(p_j)}{\partial ln(s)} = \frac{\partial ln(m_j)}{\partial ln(s)} + \frac{\partial ln(c_j)}{\partial ln(s)} \tag{3}$$

or

$$\hat{p}_{sj} = \hat{m}_{sj} + \hat{c}_{sj} \tag{4}$$

If $\hat{p}_{sj} < 1$, then pass-through is said to be incomplete while if $\hat{p}_{sj} = 1$, pass-through is complete for retailer j.

To better understand this relationship, consider the case in which movements in the exchange rate are fully passed through to costs ($\hat{c}_{sj} = 1$). This would be the case, for example, if there were no domestic inputs and retailers simply resold imported goods at a mark-up over costs. In this case then, pass-through will be incomplete if and only if the mark-up falls in response to an exchange rate depreciation ($\hat{m}_{sj} < 0$). This implies, of

course, that when prices are a constant mark-up over marginal cost, pass-through will be complete. Now if exchange rate movements are not fully passed through to costs, as would be the case for Cobb-Douglas technologies with an imported input and a domestic input, then pass-through will be incomplete when the mark-up is constant.

We can expand on the above by denoting the mark-up as

$$m_j(c, \Omega_j),$$

where $c = (c_1, c_2, \ldots, c_n)$ is the vector of retailers' costs and Ω_j is a vector of non-cost variables which affect the mark-up of retailer j (for example, the number of firms, demand parameters, the nature of competition, etc.). We assume that Ω_j is independent of the exchange rate. Thus, we can write

$$\hat{m}_{sj} = \sum_{i=1}^{n} (\hat{m}_{ij})(\hat{c}_{si}), \tag{5}$$

where $\hat{m}_{ij} = \frac{\partial \ln m_j}{\partial \ln c_i}$. Substituting this into our measure of pass-through given by equation (**??**) gives

$$\hat{p}_{sj} = \sum_{i \neq j} \hat{m}_{ij} \hat{c}_{sj} + (1 + \hat{m}_{jj}) \hat{c}_{sj}. \tag{6}$$

As equation (**??**) makes clear, differences in pass-through across industries or across time must be explained by two factors: (1) differences in how exchange rates are passed-through to costs and ($\hat{c}_{sj}$) and (2) differences in how changes in costs affect mark-ups ($\hat{m}_{ij}$). We now discuss some of these factors.

3.2 Factors affecting pass-through

There are many factors which affect the relationship between exchange rate movements and cost movements. For example, the production technology and the relative importance of imported inputs compared to domestic inputs in that technology influence this relationship. In particular, firms or countries which rely more on imported inputs will tend to have a higher degree of pass-through of exchange rate movements to costs. The location of production certainly influences this as well, so the amount of outsourcing has an effect. Furthermore, the relationship between retailers and wholesalers and each party's bargaining power affects the type of contracts they write and influences each party's exposure to exchange rate movements.

The relationship between cost movements and mark-up movements is clearly affected by demand conditions. Market structure considerations such as the number of firms in an industry, their degree of market power, and the nature of competition in the industry certainly influence this relationship as well. Thus any policy, including monetary policy,

which affects market structure could influence the degree of pass-through. A more subtle point but one which is clarified in the next section is that the degree of nominal rigidities in a market will impact on the relationship between costs and mark-ups. Hence, if monetary policy, through its effect on inflation, affects the degree of nominal rigidities, then that policy will influence the relationship between mark-ups and costs and will affect pass-through.

This approach suggests that explanations for the fall in exchange rate pass-through to prices in Canada will ultimately be explanations for why there has been a fall in pass-through of exchange rates to costs or why there has been an change in the response of mark-ups to cost movements or both. We begin by examining two approaches which suggest that the shift in monetary policy in Canada toward lower inflation has affected these relationships and, hence, exchange rate pass-through to prices.

4 Inflation and Pass-Through

This section considers the conjecture that changes in pass-through behavior may be the result of changes in monetary policy. In particular, we explore the hypothesis that the shift in monetary policy in Canada in the 1990's toward lower inflation has led to lower exchange rate pass-through in Canada. Indeed, as discussed previously, this was an argument made in the Bank of Canada's *Monetary Policy Report* (2000).

4.1 Models with Nominal Rigidities

Several papers in the open economy macroeconomics literature have examined exchange rate pass-through (or deviations from the Law of One Price) in models with nominal rigidities. Typically, these models generate incomplete pass-through in the following manner. First, they assume that firms selling in international markets set their prices in the currency of the market in which they are selling (local currency pricing). Secondly, these models incorporate a nominal rigidity by making one or more of the following assumptions: (1) Each period, firms choose prices before observing exchange rates, (2) There is some probability that any particular firm will be allowed to change their price in any period (see Calvo(1983)), (3) Firms set their prices every n periods in a staggered fashion (see Taylor (1980)), or (4) Firms must pay a cost to adjusting their price (menu costs). Models which incorporate the first assumption will generate zero sort-run pass-through of exchange rate movements to prices while the remaining assumptions will generate positive but incomplete short-run pass-through.

There are at least two explanations in this literature for a positive relationship between inflation and pass-through in the presence of nominal rigidities. In the first explanation, the inflation level affects firms' perceptions of the persistence of an exchange rate movement, which affects their response to such movements when setting prices. In the second explanation, the inflation level affects a firm's losses associated with not changing prices, and so affects its decision as to the frequency of costly change prices in response to exchange rate movements.

We briefly describe a paper by Taylor (2000) which offers the first explanation. He incorporates staggered price setting as described in method (3) above to examine pass-through of costs to prices. Because firms can only change their prices every four periods, the extent to prices respond to a movement in the exchange rate (and hence a change in the costs for importers) is increasing in the number of firms which can change prices in the period and the expected persistence of exchange rate fluctuations. He also argues that economies with low inflation are less likely to experience a persistent nominal depreciation because this would lead to extended periods of real exchange rate depreciations. Thus, low inflation economies or time periods should exhibit less pass-through than economies or episodes with high inflation.

An example of the second explanation is the paper by Devereux and Yetman (2002). They explore an environment in which firms face some exogenous probability that they will be able to change their price and an environment in which firms can adjust their price in any period at some cost. Here, we briefly describe the second environment and their results. In their model, firms import a consumer good and sell it to local consumers. The firm faces a cost of changing their price from one period to the next. Under higher inflation, firms which do not adjust prices experience loses in their real return due to exchange rate depreciations which increase their costs. Furthermore, increases in the variance of inflation will raise their expected losses from keeping their prices fixed for long periods of time. Since price adjustments are costly to firms, firms will adjust prices by less when the losses from not changing prices is low – that is, during periods of low and stable inflation.

We now frame these types of models with nominal rigidities in the basic approach discussed in the previous section which links mark-up and cost elasticities to price elasticities. Suppose retailers in that model must set prices each period before observing the exchange rate, and hence, before observing costs. As is typical in models with nominal rigidities, suppose the firms are in a monopolistically competitive industry and each firm faces a constant-elasticity of demand function with elasticity equal to $\eta > 0$. The pricing policy for firm j

can be written as

$$p_j = \left[\frac{\eta}{\eta - 1}\right] F_j(E(c_j)), \tag{7}$$

where $F_j(E(c_j))$ is a function of the firm's expectations of costs. Hence the mark-up for firm j equals

$$m_j = \frac{p_j}{c_j} = \left[\frac{\eta}{\eta - 1}\right] \left[\frac{F_j(E(c_j))}{c_j}\right]. \tag{8}$$

Now because of the nominal rigidity assumption, price and, therefore, $F_j(\cdot)$ cannot respond to the realization of the exchange rate. So, we have

$$\hat{m}_{sj} = -\hat{c}_{sj}$$

and, from equation (**??**),

$$\hat{p}_{sj} = \hat{m}_{sj} + \hat{c}_{sj} = 0.$$

So we see that the actual mark-up (in contrast to the expected mark-up) falls in proportion to a rise in costs because prices cannot respond to cost shocks and so pass-through equals zero. If a subset of firms can change their prices each period (as in Taylor(2002) or the first model of Devereux and Yetman (2003)), then pass-through to those prices will be complete but pass-through to a price index will be incomplete because other firms have zero pass-through each period. Furthermore, monetary policy, which affects the level and persistence of inflation, influences how much the *average* mark-ups respond to exchange rate movements because it affects how much firms change their prices (as in Taylor (2002)) or how often they change their prices, or both (as in Devereux and Yetman (2003)).

We conclude by noting that these models and related work which incorporate nominal rigidities and local currency pricing to study incomplete pass-through and the closely related issues of deviations from the law of one price and purchasing power parity have been criticized on a number of grounds. Obstfeld and Rogoff (2000), for example, argue that models which rely on local currency pricing are implausible because this assumption is inconsistent with evidence on the currency of trade invoicing. They also suggest that the high degree of stickiness in consumer prices needed by these models to generate persistent deviations from purchasing power parity is inconsistent with micro evidence of the frequency of price changes.

In other work which focuses on the dynamics of international prices, Chari, Kehoe, and McGratten (2002) suggest that to explain the dynamics of real exchange rates, these types of models require price stickiness of at least one year. This level of price stickiness is generally inconsistent with the evidence presented by Bils and Klenow (2004) on consumer prices which indicate that half of the prices in their sample last 4.3 months or less. It is also inconsistent with the findings of Amirault, Kwan, and Wilkinson (2005) based a recent

survey of Canadian firms' price setting behaviour. They find that one-half of firms in Canada change their prices at least once every three months. They also report that approximately one-third of the respondents now change their prices more frequently than they did a decade ago while slightly more than half of the firms have not changed the frequency of their price setting. This evidence on changes in price flexibility in Canada is difficult to reconcile with the nominal rigidities explanation for lower pass-through.

One might also conjecture that the costs of adjusting prices has fallen in the 1990's due to advances in computers and other technologies which affect inventory control. If this is the case in Canada, then the explanation offered by Devereux and Yetman which relies on a constant cost of price adjustment in the presence of low inflation since the early 1990's may be weakened.

To summarize, there is a class of models with nominal rigidities which generate the interesting *qualitative* result that pass-through is increasing in inflation. These models, however, have difficulty addressing the *quantitative* dynamic properties of exchange rate pass-through without what appears to be excessive price stickiness. This approach, then, may explain some of the fall in exchange rate pass-through in Canada but there appear to be other contributing factors.

4.2 Models with Consumer Search

In this section, we describe the model of Head, Kumar, and Lapham (2006) which incorporates costly consumer search *without* any exogenously imposed nominal rigidities. The paper examines the response of real and nominal prices to cost and money growth shocks. Here, we describe the behavior of prices in response to cost shocks, which could be interpreted as exchange rate shocks for firms which are importing goods for resale in the domestic market. The model generates incomplete pass-through and a positive relationship between inflation and pass-through.

In their environment, there is a continuum of sellers and a continuum consumers. Consumers know the distribution of prices but cannot freely observe the prices posted by an individual seller. Rather, they must pay a search cost for each price they choose to observe. Burdett and Judd (1983) demonstrate that equilibrium in this type of search environment will be characterized by a non-degenerate distribution of prices across sellers producing the same good. Because search over prices is costly for consumers, sellers have market power and can price above their marginal cost. Not surprisingly, then, mark-ups are decreasing in the search intensity of consumers. Furthermore, firms which charge high prices will typi-

cally sell to consumers who only observe one price. Thus, these high-priced firms will have more market power than firms which charge low prices (who typically sell to consumers who observe multiple prices.)

We first explain how this model generates incomplete pass-through. Suppose the marginal cost for all sellers increases (for example, the nominal exchange rate depreciates, increasing the costs for retailers which sell imported goods). Sellers pricing in different parts of the price distribution will respond to this differently so (under certain restrictions on the utility function) this will lead to increased price dispersion. This increased dispersion, in turn, increases the benefit to consumers of searching for more price quotes so search intensity will rise. This increase in search intensity will decrease the market power of all sellers and will lower the average mark-up. The only way this can happen is if the cost increase leads to a less than proportional price increase – that is, if pass-through is incomplete.

We now turn to the relationship between pass-through and inflation in the model. In equilibrium, a higher average rate of inflation is associated with a higher *average* degree of search intensity. The reasons for this are similar to those for incomplete pass-through of cost shocks. As the inflation rate rises, buyers are more willing to spend money, thus allowing sellers to raise their prices. Again, may increase in response to the cost shock for a fixed degree of search intensity. Increased price dispersion, however, raises the returns to search and thus induces buyers to increase their search intensity.

As a result, the fraction of buyers observing a single price (and thus the fraction of high market power sellers) is lower the higher is average inflation, in a stationary equilibrium. In response to a cost shock, the fewer high market power sellers there are, the weaker the increase in price dispersion arising from differential pass-through. This in turn results in a smaller increase in search intensity, and thus the pass-through of cost shocks *rises* with average inflation.

Again, to relate this model to the general approach of Section 3, consider a version of this model where the firms simply import goods for resale and so the elasticity of cost with respect to the exchange rate equals 1. In this case, equation (**??**) becomes

$$\hat{p}_{sj} = \sum_{i \neq j} \hat{m}_{ij} + (1 + \hat{m}_{jj}). \tag{9}$$

In the search environment, a firm's mark-up will respond symetrically to a change in any of its rival's costs so $\hat{m}_{ij} = \hat{m}_{i'j}$ for $i, i' \neq j$. If we denote this elasticity as $\hat{m}_{rj}$, and assume there is a unit measure of firms, then (**??**) becomes

$$\hat{p}_{sj} = 1 + \hat{m}_{rj} + \hat{m}_{jj}. \tag{10}$$

Hence, as explained above, pass-through will be incomplete because a rise in costs due to an exchange rate depreciation increases consumer search which causes firm's mark-ups to fall so $\hat{m}_{rj} < 0$ and $\hat{m}_{jj} < 0$. Thus, monetary policy which affects inflation and, thus, consumer search, affects pass-through because it changes the response of mark-ups to cost fluctuations.

To summarize this approach and relate this model to the Canadian experience, the hypothesis here is that the shift in monetary policy in Canada in the early 1990's toward lower inflation induced Canadian consumers to spend less time and resources searching for bargains. This gave Canadian retailers more market power so that movements in the exchange rate induced a larger increase in price dispersion than when inflation was high. This increased dispersion generated a bigger increase in consumer search to the exchange rate movement. The more intense search response decreased firms willingness to pass-through exchange rate fluctuations to their prices.

An interesting feature of this approach is that pass-through is incomplete in this model because firms have market power. Furthermore, shifts in the degree of pass-through are explained by changes in market power induced by changes in monetary policy. Thus, this model suggests a link between the microeconomic characteristics of an industry and the properties of pass-through in the industry. In Sections 6-8 we pursue this link more fully and consider industrial organization models of exchange rate pass-through. Before doing so, however, we now explore other forces (in addition to shifts in monetary policy) that have changed the market power of Canadian retailers by changing the market structure in that industry. We briefly discuss trends in some of the characteristics of market structure in Canadian retailing such as concentration and the "degree of competition." We suggest that these trends in the market structure of retailing may have, in turn, affected the degree of pass-through to Canadian retail prices.

5 Canadian Retailing Trends

5.1 General Restructuring

The retail sector in Canada and the United States has changed considerably over the last twenty-five years. It has seen entry and expansion of large scale firms ("big-box" retailers) particularly in the 1990s and exit of many smaller retailers. The United States Free Trade Agreement in 1989 (FTA) and the North American Free Trade Agreement in 1992 (NAFTA) also affected the sector, but to a lesser extent than the manufacturing sector. Dramatic changes in information technology, inventory management, and the introduction

of the internet were also seen during this time period. These changes have led to a shift in the relationship between retailers and manufacturers with bargaining power shifting toward large retailers. In this section, we discuss some of these changes in detail based on surveys and articles which examine trends in retail.

We begin with a brief description of some of the findings of a general survey of restructuring in Canada by Kwan (2000). This paper presents the results of a survey of 140 Canadian companies regarding the extent and timing of their restructuring activities during the 1980s and 1990s. Approximately 87% of the companies surveyed claimed that they undertook restructuring in the 1990s and 36% reported that they did so in the 1980s. In the wholesale and retail trade sector, the percentages are 86% and 27% respectively. The most common form of restructuring was adoption of a new technology but a significant percentage of firms, particularly in the retail sector identified restructuring activities which led to an increase in the size of their operations. In particular, focusing on the 1990s, approximately one-quarter of the respondents merged with another firm and one-quarter moved to fewer but larger establishments. Furthermore, 56% of firms in the retail sector stated that they introduced different formats for retail outlets which Kwan interprets as a reflection of "...more aggressive expansion strategies by 'big box' retailers..."

The survey also examines the reasons for restructuring. In the 1990s, nearly half of the firms surveyed indicated that availability of new technology was an important factor in their decision to restructure. Interestingly, in the wholesale and retail trade sector, two-thirds of the firms indicated that greater competition from Canadian firms was important while more than one-half indicated greater competition from U.S. firms. Only 5% of the firms indicated that a major change in the exchange rate led them to restructure while 18% cited the FTA and NAFTA. To summarize, Kwan's survey results suggest that retail restructuring in Canada entailed adoption of new technologies and an increase in average establishment size. Furthermore, an important factor behind these changes was **greater competition** in the sector.

A number of authors have discussed the specifics of technological changes that have significantly affected retailing in North America, including the adoption of the Universal Product Code system, improvements in the ability of suppliers and retailers to share information, changes in inventory tracking and management procedures, and the rise of automated distribution centres which ensure smooth and rapid distribution. Dunlop and Rivkin (1999) argue that large adoption costs associated with these and other advances in technology combined with the resulting lower marginal costs has led to fewer, low-cost firms, with high sales volume. Abernathy, et.al. (1995) examine the impact of these technological advances in the

apparel industry in the U.S. and argue that one effect has been increased concentration of this industry and an increase in market power for retailers on their suppliers.

Christensen and Tedlow (2000) identify major disruptions in the evolution of the retail industry. In particular, they argue that in recent years, some discount department stores were replaced by specialized discount stores ("category killers" such as Toys-R-Us and Circuit City) and by more efficient, large scale, discount retailers such as Wal-Mart. Jones and Doucet (2000) examine retail trends in the Toronto area and argue that "The most significant structural change to the North American urban retail economy in recent years has been the introduction of a variety of new retail forms – normally called 'big boxes' or 'category killers."' They go on to state that "These retail formats have introduced a new form of competition to almost every retail category." According to these authors, growth of big box retailers in Canada accelerated beginning in 1992 and peaked in 1995 with 320 big box retailers operating in Toronto in 2000. They further estimate that retail giants Wal-Mart, Home Depot, Ikea, and Toys R Us had between 19% and 44% of retail sales in their respective markets in the greater Toronto area in 2000.

As noted above, technological changes and the emergence of large retailers have shifted the balance of power from suppliers (manufacturers) toward retailers. Kumar (1996) examines this phenomenon and argues that the relationship began to change in the mid-1980s in the United States. Dunlop and Rifkin (1999) argue that prior to the adoption of the technologies described above that manufacturing companies had better information regarding demand because they were selling to a large number of retailers. In contrast, since the early to mid 1990s, large retailers have better information and often control access to a large number of consumers and can dictate their needs to their suppliers. They also suggest that the FTA and NAFTA have made the manufacturing sector in Canada more competitive and that this may have decreased manufacturers' bargaining position with retailers. This shift may have lowered costs for retailers and may allow them to write contracts with suppliers which has changed the retailers' exposure to exchange rate fluctuations.

Baldwin and Gu (2004) examine firm entry and exit and productivity growth in the Canadian retail trade sector during the 1990s. They note that this sector is characterized by a high degree of firm turnover. Their main conclusion is that much of the productivity growth in Canadian retail results from more productive entering firms displacing exiting firms that are less productive. They also argue that the importance of this entry and exit for productivity growth increase in the 1990s.

5.2 Changes in Competition

The changes in the Canadian (and U.S.) retailing sector described above suggest that the nature of competition in that sector has changed dramatically over the last fifteen to twenty years. If this is the case, then the way that prices are determined in this sector, the flexibility of those prices, and the relationship between cost movements (possibly due to exchange rate movements) and prices may have changed as well.

A survey of price-setting behaviour in Canada by Amirault, Kwan, and Wilkinson (2005) explores the question of why firms that reported increased price flexibility have adjusted their pricing behaviour. The three most important factors cited, in order of importance, were **increased competition**, increased use of information technology, and increased volatility of input costs. The discussion of changes in retailing above are consistent with the important role of the first two factors in affecting price setting behaviour in this sector. In this same survey, nearly 75% of respondents in the wholesale and retail trade sector stated that the number of competitors that they faced had changed.

A common element in the responses of firms to both of the surveys discussed above and the literature on retailing is a perception that competition has increased in this sector. Exactly what this means is an open question. At least two possibilities come to mind. First, economists often consider measures of concentration as an indication of how competitive an industry is (see Tirole (1988)) with higher concentration associated with less competition. Second, mark-ups of cost over price are often considered a measure of firms' market power with higher mark-ups associated with more market power and less competition. The question then arises as to the nature of the trends in concentration and mark-ups in the Canadian retail sector over the time period under consideration. We first discuss concentration trends.

Much of the literature on retailing trends that we have reviewed above suggests that the entry of big-box retailers and exit of smaller retailers suggests a shift in market share away from smaller firms toward much larger firms. This is suggestive of *increased concentration* in this sector in both Canada and the U.S. Baldwin and Gu (2004), however, argue that the Canadian retail sector has become slightly *less concentrated* during the 1990s as their measure of the Herfindahl concentration index decreased from .01 to .005 from 1990-1997. They also argue that over the last decade competition has become more intense in Canadian retail due to entry of big box stores from the U.S. Clearly, more work needs to be done to carefully document trends in concentration in Canadian retail.

We now turn to mark-ups as a measure of the degree of competition. As mentioned above, the surveys suggest that incumbents perceive the industry as more competitive. This suggests

that they have less market power than in the past and that their mark-ups may be lower. This is one interpretation of the survey results. It is difficult, if not impossible, however, to measure mark-ups of a particular set of firms because their costs are not observable. Instead, now examine trends in estimates of average mark-ups in Canadian retail.

To do this, we extend the methodology of Roeger (1995) to account for changes in returns to scale to provide evidence on changes in mark-ups in Canadian retailing. Our results suggest that under the assumption of constant returns to scale, the mark-up in Canadian retailing has fallen by 3% between the 1976-1983 and the 1984-1997 periods. However, this decline can also be interpreted as a rise in the returns to scale so these estimates are biased if returns to scale have also changed over this time period. Once we allow for changes in the returns to scale, we estimate that the mark-up in retail trade declined by 8% over this time period.

The methodology developed by Hall (1988) forms the basis of many approaches to studying the cyclical behavior of mark-ups. The estimating equation used in this approach is derived by manipulating a Solow residual for a production function that uses capital and labour and is homogeneous of degree γ. That equation is as follows:

$$\Delta(y_t - k_t) = m_t \alpha_t \Delta(l_t - k_t) + (\gamma - 1)\Delta k_t + \Delta a_t + \epsilon_t, \tag{11}$$

where y_t, k_t, l_t, and a_t are logs of real output, capital, labour, and a technology index. Furthermore, m_t is the mark-up and α_t is labour share. Hall (1988) pointed out that (**??**) should be estimated using an instrumental variables (IV) approach. However, it is not easy to find instruments that are sufficiently correlated with the regressors.

Roeger (1995) proposed an extension to Hall's approach that elimnated the need to use IV estimation. He showed that under constant returns to scale, the difference between the standard production-based Solow residual and the cost-based Solow residual is a function of the markup but not the technology index:

$$\Delta y_t + \Delta p_t - \alpha_t(\Delta l_t + \Delta w_t) - (1-\alpha_t)(\Delta k_t + \Delta r_t) = \left(\frac{m-1}{m}\right)(\Delta y_t + \Delta p_t - (\Delta k_t + \Delta r_t)) + \epsilon_t, \tag{12}$$

where p_t, w_t, and r_t are the price of the good, the wage, and the rental price of capital. There are two advantages to estimation this equation compared to equation (**??**). First, the technology term is not present and second, only nominal variables appear in the regression. A drawback of the approach is that it assumes constant returns.

If we relax the assumption of constant returns, then we can derive the following estimating equation:

$$\Delta y_t + \Delta p_t - \alpha_t(\Delta l_t + \Delta w_t) - (1-\alpha_t)(\Delta k_t + \Delta r_t) = \left(\frac{m-1}{m}\right)(\Delta y_t + \Delta p_t - (\Delta k_t + \Delta r_t)) + \epsilon_t, \tag{13}$$

Now note that the only difference between equation (**??**) and (**??**) is the interpretation of the coefficient on the output to capital ratio has changed. Thus, any changes over time found in Roeger's approach could also be interpreted as changes in γ. For example, a decline in m cannot be distinguished from an increase in γ.

Kee(2002) showed that (**??**) can be rearranged and expressed as

$$\Delta y_t + \Delta p_t - \alpha_t(\Delta l_t + \Delta w_t) - (1-\alpha_t)(\Delta k_t + \Delta r_t)$$

$$= (m-1)\alpha_t\left[\Delta l_t + \Delta w_t) - (\Delta k_t + \Delta r_t)\right] + (\gamma - 1)\left[\Delta k_t + \Delta r_t) - (\Delta y_t + \Delta p_t)\right] + \epsilon_t, \quad (14)$$

To overcome the collinearity problem noted by Kee(2002) in this approach, we used ridge regressions to estimate this equation. The ridge estimation is $b = (X'X + kI)^{-1}X'y$, where k is a small constant and I is the identity matrix. The value of k used here was .1. DIfferent values of k were found to change the size of the estimated coefficients but the pattern of change overtime was generally preserved.

The data used in this exercise were as follows. Quantity indices for capital, nominal gross output and labor, energy, material and service costs for retail trade are taken from Statistics Canada's KLEMS database for 1961-1997 and 1981-1997. All data are annual. Although capital costs are included in KLEMS, they are not used here because they are derived under the assumption of CRS and zero mark-ups. Instead the user cost of capital is constructed using other Statistics Canada sources. The use cost is approximated by $r = p^i(i - \pi + \delta)$, where p^i is the industry specific price of investment, i in the nominal interest rate on ten-year Government of Canada bonds, π is the growth rate of the GDP deflator, and δ is the industry specific depreciation rate.

Tables 1 and 2 present preliminary estimates of markups in the Canadian retail sector for different sub-periods. The top row of Table 1 presents estimates of the markup using the full samples of both KLEMS data sets using Roeger's original approach (see equation (**??**)). Regressions with a rolling window of nine years are estimated to examine how markups have changed over time. In each of the trade industries, there is some indication that markups have fallen at the end of the sample.

The most likely break point is found by examining the SupF statistic in the fashion of Bai and Perron (1998). If the date with the largest F-statistic is assumed to be known beforehand, a statistically significant decline in the markup can be found for retail trade during the 1980's. That is, the estimated markup falls by 3 per cent from 1.17 before 1984 to 1.13 afterward.

If we allow for increasing returns to scale using the extension of Roeger's (1995) approach given by equation (**??**), we obtain the estimates presented in Table 2. This table indicates

Table 1: Retail Average Markups Under CRS

KLEMS Vintage	1981-1997	1961-1997
Full Sample	1.1413	1.1494
	(.0249)	(.0085)
1961-1990 or 1981-1990	1.1363	1.1498
	(.0228)	(.0085)
1991-1997	1.1586	1.0833
	(.0745)	(.0680)
1961-1975		1.1250
		(.0063)
1976-1983		1.1653
		(.0024)
1984-1997		1.1261
		(.0239)

Notes: Standard errors are in parentheses. Estimates obtained using the approach of Roeger (1995) (see equation (refroeg)).

that our estimates of the markup suggest a significant fall of 8% between the 1973-1983 and the 1984-1997 periods. In addition, Figure 1 plots the average markups at the midpoints of rolloing samples with a window of nine years. For example, the markup plotted in that figure for 1993 is the average markup for the period 1989-1997. This figure suggests a decline in the average markup beginning in the late 1980s. We also see from Table 2 that our estimates of returns to scale in retail trade have decline between the 1973-1983 and the 1984-1997 periods.

These preliminary estimates suggest a decline in markups in retail where the timing of the decline is roughly in line with the decrease in exchange rate pass-through. Thus one explanation for the fall in pass-through is that the restructuring in the retail sector which has led to increased competition and, possibly, lower mark-ups may have also decreased pass-through. Exploration of such a conjecture using a theoretical model requires environments with imperfect competition and strategic price setting. We pursue this approach in the following sections. We first briefly discuss approaches in the industrial organization literature for studying pass-through with strategic firms. We then present a series of strategic price setting models and evaluate the effects of various forms of restructuring on incumbents' markups, average markups, and pass-through. We argue that a form of restructuring which is in line with the expansion of giant retailers may be generally consistent with these trends.

Table 2: Retail Average Markups and Returns to Scale

	Markup	Returns to Scale
Full Sample	1.0616	.9305
	(.0040)	(.0035)
1961-1975	1.0481	.9379
	(.0064)	(.0054)
1976-1983	1.0761	1.9304
	(.0043)	(.0038)
1984-1997	.9927	.8922
	(.0058)	(.0049)

Notes: Standard errors are in parentheses. Estimates obtained using and extension of the approach of Roeger (1995) (see equation (refkee)).

6 Industrial Organization Models of Pass-Through

As discussed above, a common modeling approach in macroeconomic models with nominal rigidities which examine pass-through and real exchange rate behaviour is to adopt a monopolistic competition industry structure. These papers also typically specify utility functions which give rise to demand functions with a constant elasticity of demand. In such an environment, firms do not interact strategically with one another but instead set prices at a constant mark-up (which is dictated by the elasticity of demand) over costs or expected costs. This approach to studying exchange rate pass-through stands in stark contrast to the more microeconomic oriented literature which began in the late 1980s. These studies emphasized industrial organization, market segmentation, and price discrimination and explored industry structures which are characterized by strategic pricing. Because of the incorporation of strategic considerations, these articles were able to shed light on links between industry characteristics and pass-through. We now briefly discuss some of the papers in this area.

One of the earliest papers in this area was by Dornbusch (1987) who explored various models of industrial organization. In each environment he presents, there are a set of domestic firms and a set of foreign firms who compete in both the home and foreign markets. The markets, however, are segmented so firms can perfectly price discriminate across markets. In this context, he explores three market structures with strategic price setting: Cournot competition with a homogeneous good; differentiated product competition where a representative consumer desires variety; and differentiated product competition with heterogeneous consumers. Exogenous movements in the exchange rate change the relative unit labour costs across domestic and foreign producers and causes equilibrium price adjustments. He demon-

strates that in these models, the extent of these equilibrium price responses to exchange rate movements depends on industry characteristics such as the degree of market concentration, product substitutability, and import penetration. Feinberg (1989) finds similar results in a model with differentiated products and conjectural variations.

More recent work has explored other environments of strategic pricing to analyze relationships between industry characteristics and pass-through. One example is Feenstra, Gagnon, and Knetter (1996) who explore price setting behaviour among domestic and foreign firms selling differentiated products and focus on the relationship between import penetration and pass-through. They demonstrate that pass-through is a non-monotonic function of firms' market shares and argue that this relationship is consistent with pass-through to automobile prices. Yang (1997) employs a model of product differentiation and variable marginal costs to argue that pass-through is related to the degree of product differentiation. Kardasz and Stollery (2001) examine pass-through in a model with a set of foreign firms and a set of domestic firms selling products which are close substitutes. Their model predicts that pass-through will depend upon, among other things, the proportion of costs accounted for by imports and number of firms in the industry.

All of the papers we have just reviewed examine pass-through in static environments. Incorporating dynamics into models with strategic price setting and pass-through is inherently difficult because of the complexities associated with analyzing dynamic games. Nonetheless, a small number of papers have done so. Froot and Klemperer (1989) examine pass-through to import prices when firms' future demands depend on current market shares in a two period duopoly model. They demonstrate that in this environment that the degree of pass-through depends on whether exchange rate movements are permanent or transitory. Lapham (1995) incorporates adjustment costs in a model with strategic price setting of differentiated products to examine the persistence properties of pass-through.

To conclude, there is a sizable literature on industrial organization models of exchange rate pass-through with strategic elements and we certainly have not provided an exhaustive survey. This section is simply meant to give the reader a sense of the approaches in this area and how these approaches differ from models of monopolistic competition with constant mark-ups. These strategic models of price setting have received little attention in the macroeconomic literature on pass-through and real exchange rates, partly because of the technical difficulty involved in analyzing strategic firms in dynamic, stochastic, general equilibrium models. This is certainly an important area for future work.

In the next section, we explore a model of a differentiated product oligopoly which is consistent with the strategic approach to pass-through. We use the model to examine various

forms of restructuring and discuss the potential for such an approach to explain the trends in Canadian retailing (including pass-through) discussed above. In Section 8, we examine a model of a homogeneous product oligopoly.

7 Differentiated Product Oligopoly Model

7.1 Industry Description

Here we consider an economy of strategic price setting among firms which produce differentiated products. Firms can compete in quantities or prices. Assume that there are initially N domestic retailers who are price setters.

There is a representative consumer who desires variety and has preferences given by

$$U(q_o, q_1, ..., q_N; \gamma), \tag{15}$$

where q_o is consumption of an outside numeraire good and q_j is consumption of differentiated good j. The parameter γ represents utility parameters which may change over time (i.e. demand shifters). These preferences give rise to the following demand function for differentiated good j

$$q_j(p_o, p_1, ..., p_N, I, \gamma), \tag{16}$$

where p_o is the price of the outside good, p_j is the price of differentiated good j, and I is the consumer's income (exogenous at this point). Letting $\mathbf{p} \equiv p_1, ..., p_N$, we denote the demand elasticity for good j as

$$\epsilon_j(p_o, \mathbf{p}, I, \gamma) \equiv \frac{\partial \ln q_j}{\partial \ln p_j} > 0 \tag{17}$$

We can also define the elasticities of this function:

$$\phi_{ji}(p_o, \mathbf{p}, I, \gamma) \equiv -\frac{\partial \ln \epsilon_j}{\partial \ln p_i} \tag{18}$$

Retaliers operate constant returns to scale technologies using domestic inputs which are priced in domestic currency and imported inputs which are priced in foreign currency. Retailers are price takers in all input markets and all face the same price of inputs. Associated with the technologies used by retailers are unit cost functions denominated in domestic currency. The cost functions are a function of the price of domestic inputs, w (expressed in domestic currency), the price of imported inputs, w^F (expressed in foreign currency), and the spot exchange rate, s (domestic currency per unit of foreign currency). The unit cost function for retailer j is denoted $c_j(s, w, w^F)$.

The profit maximization problem for firm j is

$$\max_{p_j} \Big[p_j - c_j(s, w, w^F) \Big] q_j(p_o, \mathbf{p}, I, \gamma).$$

The first-order necessary condition for retailer j is the familiar expression

$$p_j \left(1 - \frac{1}{\epsilon_j} \right) = c_j$$

or

$$p_j = \left(\frac{\epsilon_j}{\epsilon_j - 1} \right) c_j \tag{19}$$

Solving this system of N equations gives equilibrium prices, $p_j^*(s, w, w^F, I, \gamma, N)$ and the equilibrium price vector $\mathbf{p}^*$.

7.2 Equilibrium Pass-Through

Logging and differentiating this with respect to the log of the exchange rate gives the following system of N equations for equilibrium pass-through by each firm:

$$\beta_j = \frac{-\sum_{i=1}^{N} \phi_{ji}^* \beta_i}{\epsilon_j^* - 1} + \hat{c}_{js}, \tag{20}$$

where $\phi_{ji}^* \equiv \phi_{ji}(p_o, \mathbf{p}^*, I, \gamma)$, $\epsilon_j^* \equiv \epsilon_j(p_o, \mathbf{p}^*, I, \gamma)$, $\mathbf{p}^*$, and $\hat{c}_{js}$ is the elasticity of the cost function with respect to the exchange rate. Now solving this system of N equations gives equilibrium pass-through of exchange rates to the price of each retailer: $\beta_j^*(s, w, w^F, I, \gamma, N)$

If we consider a symmetric equilibrium in which $\forall j$, $c_j = c$, $\epsilon_j^* = \epsilon^*$, $\phi_{jj}^* = \phi^*$, and $\phi_{ji}^* = \nu^*$, then equilibrium pass-through by an individual retailer equals

$$\beta^*(s, w, w^F, I, \gamma, N) = \left[\frac{\epsilon^* - 1}{\epsilon^* - 1 + \phi^* + (N-1)\nu^*} \right] \hat{c}_s. \tag{21}$$

Now, under constant-returns-to-scale production, we know that $0 < \hat{c}_s \leq 1$ and $\hat{c}_s = 1$ if there are no domestic inputs. Given that empirical estimates of pass-through are generally less than one (incomplete pass-through), we wish to restrict attention to environments in which pass-through is no greater than one even in the absence of domestic inputs. We see from equation (**??**) that this requires restricting attention to utility functions which give rise to demand functions for which $\phi^* + (N-1)\nu^* > 0$ in the symmetric case.

In the symmetric case, we first consider the question as to whether a change in an economy parameter (which we will term as a *"minor restructuring"*) can simultaneously lead to lower pass-through and more competition as measured by lower average mark-ups. In the next section we consider more major forms of restructuring under a specific form of the utility

function which has been used in other applications in international economics. Consider, for example, a change in the number of firms (simple exogenous entry or exit.)

The elasticity of the equilibrium price and the mark-up of a representative firm with respect to the number of firms under symmetry is given by

$$\hat{p}_N^* = \frac{-\epsilon_N^*}{\epsilon^* - 1 + \phi^* + (N-1)\nu^*}.$$

We generally expect $\hat{\epsilon}_N^* \geq 0$ so we expect the price and mark-up to be non-increasing in the number of firms. Thus, if we associate an increase in competition with a fall in mark-ups, then to generate such a change with this form of minor restructuring, we would require a rise in the number of firms (and an associated fall in concentration). The question then arises as to whether such an increase in the number of firms would also lead to a fall in pass-through.

Unfortunately, without a specific form of utility and, therefore, demand, the derivative of the pass-through expression given by equation (**??**) with respect to the number of firms cannot be signed in general. However, we have examined this derivative for a number of specific demand functions including (1) constant-elasticity-of substitution demand functions with a large number of firms, (2) constant-elasticity-of substitution demand functions with a small number of firms, (3) a characteristics approach to differentiated products where consumers are distributed around a circle according to their ideal variety (Salop (1979)), and (4) those arising from the utility function analyzed in the next subsection. In all of those examples pass-through is non-decreasing in the number of firms (the derivations for the first three specifications are not included in the paper). Hence, a rise in the number of firms appears to increase pass-through under many specifications for differentiated products.

These results suggest that in this type of model, exogenous entry and exit alone cannot simultaneously generate a situation of increased competition (i.e. a fall in mark-ups) and a fall in pass-through. Another possible form of minor restructuring would be a change in the degree of product substitutability among the differentiated products. In the general specification above, we do not have a single parameter which controls this (although an element of γ could be interpreted as such). However, we would generally expect an increase in product substitutability to decrease prices and mark-ups in equilibrium. Again, determining the effect on pass-through is difficult but as mark-ups fall we expect them to become less sensitive to cost changes and, hence, we expect more pass-through. It is shown in the next subsection that this conjecture is verified for the specific form of the utility function analyzed there. Thus, again such a minor restructuring has difficulty generating an industry characterized by both more competition and lower pass-through. We now turn to an analysis of more major forms of restructuring with a specific demand function.

7.3 "Major" Restructuring

As the discussion of Canadian retailing trends in Section 5 suggests, this sector appears to have faced more significant changes than can be captured by simple comparative statics exercises on economy parameters. An alternate approach is to consider the possibility that restructuring caused the **form of competition** in the retail sector to change. In this case, the change could potentially lead to lower pass-through *and* a perception by incumbents that the industry is more competitive. We consider three possible forms of restructuring which could be argued to be in the spirit of the trends discussed in Section 5 (i.e. entry by big box retailers with a cost advantage and exit of smaller retailers.) They are as follows: (1) Entry by a lower cost firm with all firms choosing prices simultaneously (a Nash equilibrium); (2) Entry by a firm with the same costs as incumbents with the entrant choosing her price before her rivals (a symmetric Stackelberg equilibrium); and (3) Entry by a lower cost firm with the entrant choosing her price before her rivals (an asymmetric Stackelberg equilibrium). In each of these cases, we also allow for exit by a subset of incumbents. Now, the first restructuring could be interpreted as the case in which Wal-Mart enters with a cost advantage but does not act as a price leader. The second is Wal-Mart entering with no cost advantage but acting as a price leader and the third is this case but with Wal-Mart enjoying a cost advantage. It might be argued that the final case best captures the retail trends discussed in Section 5.

To analyze these three forms of major restructuring, we specify a particular form for the utility function which is tractable yet which leads to strategic interaction among retailers in a price setting game. The preference specification we use is taken from Melitz and Ottaviano (2005):

$$U = q_o + \delta \int_{i\in\Omega} q_i di - .5\sigma \int_{i\in\Omega} (q_i)^2 di - .5\eta \left(\int_{i\in\Omega} q_i di \right)^2, \tag{22}$$

where we have assumed there is a continuum of differentiated products and Ω is the set of those products. The measure of products equals N. There is a unit measure of consumers all with the same utility function. Now increases in $\delta > 0$ and decreases in $\eta > 0$ increase the demand for differentiated goods relative to the outside good. In addition, the degree of product differentiation is increasing in $\sigma > 0$. It is assumed that there is positive demand for the outside good. These preferences give rise to the following demand function for good j:

$$q_j = \frac{\delta}{\sigma + \eta N} - \frac{1}{\sigma} p_j + \left(\frac{\eta N}{\sigma(\sigma + \eta N)} \right) \bar{p}, \tag{23}$$

where $\bar{p} \equiv (1/N) \int_{i\in\Omega} p_i di$ is the average price. We note that when a retailer chooses her price to maximize profits, she takes $\bar{p}$ as given because there is a continuum of firms.

Each retailer operates a constant returns to scale technology given by

$$y_j = z_j m_j^{\alpha_j} l_j^{1-\alpha_j}, \tag{24}$$

where z_j is a firm specific technology parameter, m_j is input of imported goods, and l_j is input of domestic labor. Imported intermediates are denominated in foreign currency and have a unit price of w^F. The domestic wage is w and the spot exchange rate (domestic to foreign currency) is denoted s. This gives rise to the following unit cost function for retailer j (in domestic currency units):

$$c_j(s, w, w^F) = \frac{(sw^F)^{\alpha_j} w^{1-\alpha_j}}{z_j \left(\alpha_j^{\alpha_j}(1-\alpha_j)^{1-\alpha_j}\right)} \tag{25}$$

Thus, we have the following elasticity of the cost function with respect to the exchange rate for retailer j:

$$\hat{c}_{js} = \alpha_j \tag{26}$$

We first consider a symmetric equilibrium in which firms all face the same technologies: $z_j = z$ and $\alpha_j = \alpha \ \forall j$. In this case, the equilibrium price of each good and equilibrium exchange rate pass-through are given by

$$p^* = \frac{(\sigma + \eta N)c + \sigma\delta}{2\sigma + \eta N} \tag{27}$$

$$\beta^* = \left(\frac{(\sigma + \eta N)c}{(\sigma + \eta N)c + \sigma\delta}\right)\alpha. \tag{28}$$

Now, we see from the latter expression that $0 < \beta^* < 1$ because σ and δ are both positive and $0 < \alpha < 1$. We also derive the equilibrium mark-up:

$$\mu^* \equiv \frac{p^*}{c} = \frac{(\sigma + \eta N)c + \sigma\delta}{(\eta N)c}. \tag{29}$$

Consider again, briefly the minor restructuring discussed in the last subsection. These expressions imply that an increase in the measure of firms, N will lead to a fall in the price and the mark-up and a rise in pass-through (as conjectured in the previous section). A fall in σ, which implies a rise in product differentiation has the same effect. We find similar results for changes in the other parameters of the utility function. Thus, this economy supports the hypothesis that minor changes in the economy cannot reconcile both increased competition (lower mark-ups) and lower pass-through. We now consider the three forms of major restructuring listed above.

Imagine that the economy is in the symmetric equilibrium described here. Then suppose that a single firm enters with a superior technology that gives rise to a lower unit cost than

existing firms. Let variables for this retailer be denoted with an "L" so her technology is given by

$$y_L = z_L m_L^{\alpha} l_L^{1-\alpha}.$$

Let variables for the incumbents be denoted with an "H" and their technologies are characterized by $z_H < z_L$ and $\alpha_H = \alpha_L = \alpha$. This, of course gives rise to the following relationship between unit costs: $c_H(s, w, w^F) > c_L(s, w, w^F)$. Firms choose prices simultaneously and we consider various levels of exit of incumbents.

In Appendix 1 (forthcoming), we derive equilibrium levels of prices for the low cost entrant and the high cost incumbents as a function of preference parameters, costs of each type of retailer, and the number of retailers in this asymmetric Nash equilibrium. Let those equilibrium prices be denoted p_L^* for the entrant and p_H^* for each incumbent. We also denote the mark-up of each type of firm as $\mu_j^* \equiv p_j^*/c_j^*$ for $j \in [L, H]$.

Now we seek to examine pass-through of exchange rate movements to an average price for the industry. We construct such a price index using a weighted average of firms' prices with weights equal to expenditure (market shares). This is broadly consistent with construction of the CPI in the data.

Let the market share of a type $j \in [L, H]$ firm be denoted r_j with

$$r_j \equiv \frac{p_j^* q_j^*}{p_L^* q_L^* + (N-1) p_H^* q_H^*}, \tag{30}$$

where q_j^* is equilibrium output by a type j firm, and N is the total number of retailers operating in the industry. Then the equilibrium price index is defined as follows:

$$P^* = r_L p_L + (N-1) r_H p_H. \tag{31}$$

Our measure of pass-through then is defined as the elasticity of this price index with respect to the exchange rate .

We are also interested in a measure of the average mark-up as well as the individual mark-ups μ_L and μ_H. It is not obvious how to measure the average mark-up so we consider three alternative measures as follows:

$$\bar{\mu}_1^* \equiv \frac{\bar{p}^*}{\bar{c}}. \tag{32}$$

$$\bar{\mu}_2^* \equiv \frac{P^*}{\bar{c}}. \tag{33}$$

$$\bar{\mu}_3^* \equiv r_L \mu_L + (N-1) r_H \mu_H, \tag{34}$$

where $\bar{c} = (c_L + (N-1)c_H)/N$ is average cost. Below we examine the effects of restructuring on each of these measures of the average mark-up.

Now, even with a particular specification for the demand function, it is difficult to perform analytical comparisons between the original symmetric Nash economy and this asymmetric Nash economy. Instead, we present the results of numerical experiments to determine the effects of this form of restructuring on pass-through and both firm level and average mark-ups. In each of the experiments, we choose the following economy parameters for illustrative purposes but our general conclusions do not appear sensitive to our choices. For preferences, we chose $\delta = 1.2$, $\sigma = 2.5$, $\eta = .05$. We set the number of firms in the original equilibrium (before entry) at $N = 10$. For technology parameters, we chose $z_H = 2$, $z_L = 2.5$, $\alpha = .4$ and for the exchange rate and input prices we use $s = w = w^F = 1$. These values implied average and firm-level markups of approximately $\mu^* = 10\%$ and a pass-through coefficient of approximately $\beta^* = .2$ in the symmetric Nash equilibrium. These values are not inconsistent with empirical estimates prior to the fall in pass-through in Canada.

In what follows we present figures which depict percentage differences in relevant economy variables under the restructuring from their equilibrium values before the restructuring (i.e. in the symmetric Nash equilibrium) for various levels of exit of incumbents. Figures 2-3 presents these values for the price index, pass-through, and our three measures of the average mark-up, while Figure 4 depicts firm-level mark-ups under the first form of restructuring. We see from Figure 2 that entry by the low cost firm, not surprisingly, lowers the price index in the industry. The entry of a low cost firm also leads to lower levels of pass-through and higher levels of average mark-ups, although the degree of the increase depends on our measure of this variable. Figure 4 shows, as expected, that incumbents prices and mark-ups fall when the new firm enters if exit is limited. Of course, if there is enough exit, incumbents enjoy more market power and their prices and mark-ups may rise above their original level.

We conclude from this exercise (and exercises with other economy parameter values) that entry by a low cost firm alone lowers pass-through and may decrease the mark-ups of incumbents (and, thus, lead a perception on their part that the market is more competitive.) We do see, however, that our measures of the average mark-up rise due to the market power of the low-cost entrant. Thus, this form of restructuring could lead to lower pass-through and a view by incumbents of more competition as their mark-up falls, perhaps leading to exit. We now consider two other forms of more major restructuring.

We again imagine that the economy is initially in the symmetric Nash equilibrium. Now suppose that a firm enters the industry with the same technology as incumbents but the entrant sets her prices *before* her rivals and, therefore, acts as a Stackelberg leader. We can again derive firm-level prices and mark-ups for the followers and the leader and these are presented Appendix 1 (forthcoming). We construct a price index and measures of average

mark-ups in the same manner as in equations (**??**) - (**??**) and examine pass-through to the price index. Note that under symmetric costs, the three measures of average mark-ups are equivalent. Figures 5-7 depict the same variables as Figures 2-4 but for the symmetric Stackelberg economy. Figure 5 shows that pass-through will fall under this restructuring only with sufficient exit. A comparison of Figure 5 with Figures 6 and 7 shows, however, that this much exit will also lead to a rise the average mark-up and in the mark-ups of incumbents which we have argued is inconsistent with their perception of a more competitive environment. Thus, we would conclude that this form of restructuring is not consistent with both lower pass-through and a higher perceived level of competition.

In our final restructuring exercise, we allow the entrant to have a superior technology *and* to act as a price leader in the price setting game. Figures 8-10 show variables for this asymmetric Stackelberg case. Here we see that this form of restructuring leads to a fall in pass-through even when there is no exit by incumbents. Figure 10 further demonstrates that if exit by incumbents is limited then the mark-up of remaining incumbents falls as well. Thus, we have an economy in which entry by a low-cost price leader generates both a fall in pass-through and a fall in incumbents mark-ups. We also see, however, that this change increases our measure of average mark-ups (although the second measure rises by very little) because the entrant enjoys considerable market power and has relatively high mark-ups.

We see then that the conclusions we drew for the asymmetric Nash case hold in the asymmetric Stackelberg case as well but the quantitative effects are stronger in the latter case. Comparing Figures 2 and 8, we see that pass-through falls by more in the Stackelberg equilibrium than in the Nash equilibrium. We also see that the mark-up by incumbents falls by more in the Stackelberg case by comparing Figures 4 and 10.

One might argue that the last form of restructuring we considered may be the closest to capturing some of the features of entry by big-box retailers such as Wal-Mart into Canada. Our final results suggest that this form of restructuring may be part of the explanation for the fall in pass-through of exchange rates to retail prices in Canada. We also note that if these large retailers are able to write contracts which insulate their costs more from exchange rate movements than their smaller rivals (i.e. they have a lower α), then pass-through after their entry would be even lower than in the case presented above. Clearly, further work needs to be done to quantify the effects we have identified and generalize the results to other forms of demand functions. We now turn to a similiar analysis in an economy with homogeneous products.

8 Homogeneous Product Models

8.1 Industry Description

We now examine an economy of strategic price setting among identical firms. Assume that the industry consists of N retailers who produce a homogeneous good and choose quantities.

Let the demand function for the good of interest be represented by an inverse demand function given by

$$P(Q, p_o, I, \gamma) \tag{35}$$

where Q is total output of the good, p_o is the price of an outside good (the numeraire), I is income, and γ is a vector of preference and economy parameters which affect demand.

Denote the demand elasticity for this good as follows:

$$\epsilon(p, p_o, I, \gamma) \equiv -\frac{\partial \ln Q}{\partial \ln p}. \tag{36}$$

Note that $\epsilon > 0$. We also denote the elasticity of this function by

$$\phi(p, p_o, I, \gamma) \equiv \frac{\partial \ln \epsilon}{\partial \ln p}. \tag{37}$$

Finally, below we will also need the elasticity of $\phi(cdot)$ itself and will denote it by

$$\psi(p, p_o, I, \gamma) \equiv \frac{\partial \ln \phi}{\partial \ln p}. \tag{38}$$

For our purposes, ϵ, ϕ, and ψ will be sufficient to characterize the properties of the demand function which are relevant for pass-through. All firms face the same technology as described in the previous section and are summarized by unit cost functions.

Let q_j denote the output of firm j and we note that $Q \equiv \sum_{j=1}^{N} q_j$. The profit maximization problem for firm j is

$$\max_{q_j} \left[P\Big(Q, p_o, I, \gamma\Big) - c(s, w, w^F) \right] q_j. \tag{39}$$

The first-order necessary condition for retailer j is the familiar expression

$$p\left(1 - \frac{q_j}{\epsilon Q}\right) = c \tag{40}$$

In the symmetric equilibrium, $q_j = q$ for all j and $Q = Nq$. Substituting this into the firm's first-order necessary condition gives the equilibrium price of the good as a function of the exchange rate and industry variables:

$$p^*(s, Z) = \left[\frac{N\epsilon^*(s, Z)}{N\epsilon^*(s, Z) - 1}\right] c \tag{41}$$

where $Z \equiv (w, w^F, p_o, I, \gamma, N)$ and $\epsilon^*(s, Z) \equiv \epsilon(p^*(s, Z), p_o, I, \gamma)$.

8.2 Equilibrium Pass-Through

Logging and differentiating the equilibrium price with respect to the log of the exchange rate gives our expression for pass-through:

$$\beta^*(s,Z) = \left[\frac{N\epsilon^*(s,Z)-1}{N\epsilon^*(s,Z)-1+\phi^*(s,Z)}\right]\hat{c}_s \tag{42}$$

where $\phi^*(s,Z) \equiv \phi(p^*(s,Z),p_o,I,\gamma)$ and $\hat{c}_s > 0$ is the elasticity of the cost function with respect to the exchange rate. Henceforth, the arguments (s,Z) of equilibrium functions are suppressed so we can write equation (**??**) as

$$\beta^* = \left[\frac{N\epsilon^*-1}{N\epsilon^*-1+\phi^*}\right]\hat{c}_s. \tag{43}$$

We also note that the equilibrium mark-up is given by

$$\mu^* = \left[\frac{N\epsilon^*}{N\epsilon^*-1}\right]. \tag{44}$$

As in the previous section, we wish to restrict attention to environments in which pass-through is no greater than one even in the absence of domestic inputs. We see from equation (**??**) that this requires restricting attention to demand functions for which the elasticity of demand is non-decreasing in price ($\phi^* \geq 0$). As is clear from equation (**??**) and the discussion in Section 3, this restriction on demand implies that equilibrium mark-ups will be non-increasing functions of the exchange rate. We can also clearly see from these expressions that for demand functions which exhibit constant elasticity of demand ($\phi^* = 0$), that the mark-up is constant and exchange rate pass-through to price is completely determined by exchange rate pass-through to costs.

When the mark-up is not constant, these equations demonstrate that this Cournot model of strategic pricing has the feature that market conditions (N), demand conditions (p_o, I, γ), and cost conditions (including the exchange rate) ($s, w^F, w, \hat{c}_s$) will generally affect the pass-through of exchange rates to prices. To better understand these effects, the following table gives the price, mark-up, and pass-through elasticities with respect to the parameters of the model.

Table 3: Price, Mark-up, and Exchange Rate Pass-Through Elasticities in Cournot Model

Variable	Price	Mark-Up	Exchange Rate Pass-Through
n	$\frac{-1}{n\epsilon^*-1+\phi^*}$	$\frac{-1}{n\epsilon^*-1+\phi^*}$	$\frac{\phi^*(n\epsilon^*+\psi^*)}{(n\epsilon^*-1+\phi^*)^2}$
P^0	$\frac{-(\hat{\epsilon}_0^*)}{n\epsilon^*-1+\phi^*}$	$\frac{-(\hat{\epsilon}_0^*)}{n\epsilon^*-1+\phi^*}$	$\left[\frac{\phi^*}{(n\epsilon^*-1+\phi^*)^2}\right]\left[(n\epsilon^*+\psi^*)(\hat{\epsilon}_0^*)-(n\epsilon^*-1+\phi^*)(\hat{\phi}_0^*)\right]$
E	$\frac{-(\hat{\epsilon}_E^*)}{n\epsilon^*-1+\phi^*}$	$\frac{-(\hat{\epsilon}_E^*)}{n\epsilon^*-1+\phi^*}$	$\left[\frac{\phi^*}{(n\epsilon^*-1+\phi^*)^2}\right]\left[(n\epsilon^*+\psi^*)(\hat{\epsilon}_E^*)-(n\epsilon^*-1+\phi^*)(\hat{\phi}_E^*)\right]$
γ	$\frac{-(\hat{\epsilon}_\gamma^*)}{n\epsilon^*-1+\phi^*}$	$\frac{-(\hat{\epsilon}_\gamma^*)}{n\epsilon^*-1+\phi^*}$	$\left[\frac{\phi^*}{(n\epsilon^*-1+\phi^*)^2}\right]\left[(n\epsilon^*+\psi^*)(\hat{\epsilon}_\gamma^*)-(n\epsilon^*-1+\phi^*)(\hat{\phi}_\gamma^*)\right]$
s	$\left(\frac{n\epsilon^*-1}{n\epsilon^*-1+\phi^*}\right)\hat{c}_s$	$\left(\frac{-\phi^*}{n\epsilon^*-1+\phi^*}\right)\hat{c}_s$	$\left[\frac{\phi^*\hat{c}_s}{(n\epsilon^*-1+\phi^*)^2}\right][(n\epsilon^*(\phi^*-\psi^*)+\psi^*)]+\frac{\partial ln(\hat{c}_s)}{\partial ln(s)}$
w^F	$\left(\frac{n\epsilon^*-1}{n\tilde{\epsilon}^*-1+\phi^*}\right)\hat{c}_F$	$\left(\frac{-\phi^*}{n\tilde{\epsilon}^*-1+\phi^*}\right)\hat{c}_F$	$\left[\frac{\phi^*\hat{c}_s}{(n\epsilon^*-1+\phi^*)^2}\right][(n\epsilon^*(\phi^*-\psi^*)+\psi^*)]+\frac{\partial ln(\hat{c}_s)}{\partial ln(w^F)}$
w	$\left(\frac{n\epsilon^*-1}{n\tilde{\epsilon}^*-1+\phi^*}\right)\hat{c}_w$	$\left(\frac{-\phi^*}{n\tilde{\epsilon}^*-1+\phi^*}\right)\hat{c}_w$	$\left[\frac{\phi^*\hat{c}_s}{(n\epsilon^*-1+\phi^*)^2}\right][(n\epsilon^*(\phi^*-\psi^*)+\psi^*)]+\frac{\partial ln(\hat{c}_s)}{\partial ln(w)}$

In this table, $\psi^* \equiv \psi(p^*, p_o, I, \gamma)$ and the elasticities ϵ, ϕ, and ψ, are as defined by equations (**??**), (**??**), and (**??**) evaluated at the equilibrium price. This table demonstrates that a general determination of the effect of changes in demand conditions, technologies, factor prices, and market conditions on exchange rate pass-through will be difficult in the presence of strategic pricing.

We now turn the question of whether minor restructuring in such a model can simultaneously lead to lower pass-through and lower mark-ups. Consider first a change in the number of firms. From Table 3, we see that a rise in N will decrease both the price and the mark-up, as expected. The table also indicates that the sign of the pass-through elasticity with respect to the number of firms is given by the sign of $N\epsilon + \psi > 0$. This is difficult to sign for general demand functions, however, in the demand example we consider below and in the examples presented in Appendix 2, this expression is always non-negative indicating that pass-through is increasing in the number of firms. So, a rise in the number of firms which lowers the mark-up will *increase* pass-through. This is consistent with our findings in the differentiated product model presented in the previous section.

8.3 "Major" Restructuring

As in the differentiated product model, we seek to determine the effects on mark-ups and pass-through of the three types of restructuring described above. We begin by comparing the symmetric Nash equilibrium to an asymmetric Nash equilibrium as follows. Consider

an industry with $N' \leq N$ firms of two types. There are $H \geq 0$ firms who have identical technologies to the firms in the symmetric equilibrium ("high cost firms") and we denote their cost function as $c_H(s, w, w^F)$. There are $L = N' - H$ firms who have technologies which give rise to a unit cost function given by $c_L(s, w, w^F)$ with $c_L < c_H$ and with an exchange rate elasticity given by $\hat{c}_{Ls} \leq \hat{c}_{Hs}$. These are "low cost firms" with superior technologies and costs which are possibly more insulated from exchange rate movements. We assume that these new firms replace existing firms one-for-one so the number of firms stays constant or that there is more exit of old firms than entry of new firms so the total number of firms falls. Let C' denote total costs in the new equilibrium with $C' \equiv Hc_H + Lc_L$.

We can show that this new equilibrium will be characterized by the following equilibrium price and pass-through equations

$$p' = \left[\frac{\epsilon'}{N'\epsilon' - 1}\right] C' \tag{45}$$

$$\beta' = \left[\frac{N'\epsilon' - 1}{N'\epsilon' - 1 + \phi'}\right] \hat{C}'_s, \tag{46}$$

where $\epsilon' \equiv \epsilon(p', p_o, I, \gamma)$, $\phi' \equiv \phi(p, p_o, I, \gamma)$, and $\hat{C}'_s = \frac{Hc_H\hat{c}_{Hs} + Lc_L\hat{c}_{Ls}}{C'}$. As before, we restrict attention to preferences for which $\phi' > 0$ so that pass-through is incomplete even when there are no domestic inputs.

Let the average mark-up be defined as the ratio of price to average cost and denote it $\bar{\mu}'$:

$$\bar{\mu}' = \frac{N'p'}{C'}, \tag{47}$$

where we have used $\frac{C'}{N'}$ to measure average cost.

Letting a superscript $*$ denote equilibrium values in the symmetric Cournot Nash equilibrium, we have the following proposition which compares prices, mark-ups, and pass-through between the two economies.

Proposition 1:

1. (a) If $N' = N$, $p' < p^*$
   (b) If $N' < N$, the price effect is ambiguous
2. $\bar{\mu}' > \mu^*$
3. If $N\epsilon'(\phi' - \psi') + \psi' > 0$, then
   (a) If $N' = N$, $\beta'_s \leq \beta^*_s$
   (b) If $N' < N$ and $p' < p^*$, $\beta'_s \leq \beta^*_s$

Proofs of propositions are available from the author upon request.

This proposition states that if the number of firms does not fall in the new equilibrium, then the new price will be lower because average costs are lower. If, however, there is enough exit, then the lower degree of competition due to exit can lead to higher prices. We also see that the new equilibrium will be characterized by higher average mark-ups. The average mark-up rises when the price falls because incomplete pass-through implies that the fall in average costs is not fully passed through to the price. By definition, the average mark-up must rise when the price rises and the average cost falls. Thus, this approach to modeling restructuring does not lead to lower average mark-ups.

Regarding pass-through, if the sufficient condition of part (3) of the proposition is met, then pass-through falls because low cost firms potentially have lower cost elasticities and because the presence of lower cost firms increases competition which induces lower pass-through. Note that the condition of the proposition is sufficient but not necessary for lower price pass-through. In particular, if the condition of the proposition holds, then lower pass-through of exchange rates to costs by low cost firms is sufficient but not necessary for lower pass-through of exchange rates to prices. In all the demand examples we considered below the condition is met and pass-through is lower in the asymmetric equilibrium.

To summarize, this type of a shift in the industry where a subset of firms experience a fall in costs but firms continue to play a Nash quantity setting game is consistent with lower pass-through, but not lower mark-ups. We now examine the two remaining forms of restructuring.

We now compare the symmetric Cournot Nash equilibrium to an equilibrium with $N' \leq N$ firms where one of the firms is a Stackelberg leader. There are $N' - 1$ firms with the same unit cost function ($c_H(\cdot)$) as in the symmetric Cournot Nash economy who are followers. The leader has unit costs, $c_L(\cdot)$, which may be lower than the followers and has a cost elasticity with respect to the exchange rate which is no larger than the followers.

Let q_L be the equilibrium output of the Stackelberg leader and let q_H be the equilibrium output of a representative follower. Then equilibrium aggregate output in this environment is $Q' \equiv q_L + (H' - 1)q_H$. We begin with the profit maximization problem of a representative follower. Follower firm j faces the following problem

$$\max_{q_j} \left[P\Big(Q, p_o, I, \gamma\Big) - c_H(s, w, w^F) \right] q_j.$$

Taking the first-order condition for a solution to this maximization problem and imposing symmetry among the followers allow us to derive the following expression which implicitly defines the best response of followers to a quantity choice by the leader which we denote as

$\tilde{q}_H(q_L)$:

$$(\tilde{p} - c_H)(\tilde{\epsilon}\tilde{Q}) - \tilde{p}\tilde{q}_H = 0, \tag{48}$$

where $\tilde{Q} = q_L + (N' - 1)\tilde{q}_H$, $\tilde{p} = P(\tilde{Q}, p_o, I, \gamma)$, and $\tilde{\epsilon} = \epsilon(\tilde{p}, p_o, I, \gamma)$.

The Stackelberg leader faces the following problem

$$\max_{q_L} \left[P\Big(\tilde{Q}, p_o, I, \gamma\Big) - c_L(s, w, w^F) \right] q_L.$$

The first-order necessary condition for the leader can be rearranged and combined with the best response function of the followers and the industry demand function to derive the system of equilibrium equations. These equations are given below and can be solved to determine the equilibrium industry price output of the leader:

$$p' = \left[\frac{\epsilon' Q'}{\epsilon' Q' - q_L \left(\frac{d\tilde{Q}}{dq_L} \right)} \right] c_L \tag{49}$$

$$q_H = \tilde{q}_H(q_L) \tag{50}$$

$$p' = P(Q', p_o, I, \gamma) \tag{51}$$

Now, this is a complicated system of equations and it is difficult to draw any general conclusions regarding mark-ups and pass-through with general demand. Instead, as with the differentiated products model, we specify a particular demand function which is tractable and present results for that example.

8.3.1 Linear Demand Example

Let the inverse demand function for the good of interest be given by

$$p = \gamma - \delta Q$$

with $\gamma > c$, $\delta > 0$. We can derive the equilibrium price and pass-through coefficient in the symmetric Nash equilibrium:

$$p^* = \frac{\gamma + Nc}{N + 1} \qquad\qquad \beta^* = \left[\frac{Nc}{\gamma + Nc} \right] \hat{c}_s \tag{52}$$

We note that $\phi^* > 0$, so pass-through is less than one even in the absence of domestic inputs and that $N\epsilon^* + \psi^* = \epsilon^*(N + 1) > 0$, so pass-through is increasing in the number of firms. Thus, with linear demand, a rise in the number of firms decreases the mark-up but increases pass-through.

In the Stackelberg economy, the best response function for the followers under the linear demand function specified above is

$$\tilde{q}_H(q_L) = \frac{\gamma - c_H - \delta q_L}{\delta N'}$$

and

$$\frac{d\tilde{Q}}{d\tilde{q}_L} = \frac{1}{N'}.$$

Substituting these into the above equations and rearranging gives the equilibrium price in the Stackelberg economy:

$$p' = \frac{\gamma + (N'-1)c_H + N'c_L}{2N'}$$

Pass-through in the Stackelberg equilibrium is given by

$$\beta' = \frac{(N'-1)c_H\hat{c}_{Hs} + N'c_L\hat{c}_{Ls}}{\gamma + (N'-1)c_H + N'c_L}$$

Now, we first focus on the case where the leader has the same unit cost function as the followers and denote this function by $c(\cdot)$. We can show the following proposition in the linear symmetric case:

Proposition 2

If firms have identical cost functions and demand is linear, then

1. Prices and mark-ups are lower in the Stackelberg equilibrium than in the Nash equilibrium if and only if
$$N' > \frac{N+1}{2}.$$
2. Pass-Through is lower in the Stackelberg equilibrium than in the Nash equilibrium if and only if
$$N' < \frac{N+1}{2}.$$

This proposition implies that with linear demand, we cannot simultaneously achieve lower mark-ups and lower pass-through through this form of restructuring. In particular, if there is sufficient exit, then pass-through will fall but the exit will lead to higher mark-ups.

We now turn to the case in which the leader has a cost advantage. Clearly the industry price in this case will be lower than in the symmetric Stackelberg equilibrium. Hence, Proposition 2 gives a sufficient but not necessary condition for $p' < p^*$ with cost differences. Comparisons between mark-ups and pass-through between the two economies are difficult to make even with this specific demand function. Hence, to make these comparisons, we resort to numerical examples.

To illustrate that the economy with Stackelberg competition with a leader with a cost advantage can simultaneously generate lower mark-ups and lower pass-through , we present a illustrative numerical example with the following economy parameters: $\gamma = 2$, $\delta = 1$, $s = w^F = w = 1$. We let the technologies be given by the Cobb-Douglas production functions specified in the differentiated products model. When we assume that firms have

identical technologies, we let $z_j = 2\ \forall j$ and $\alpha_j = .5\ \forall j$. When firms have asymmetric costs but symmetric cost elasticities with respect to the exchange rate, we let the high cost firms have $z_H = 2$ and low cost firms have $z_L = 2.5$. Under asymmetric cost elasticities, we let $\alpha_H = .5$ and $\alpha_L = .4$ so firms with α_L have lower cost elasticities with respect to the exchange rate.

Figures 11-13 present the percentage differences between the alternate economies with symmetric cost elasticities and the benchmark economy of symmetric Nash competition for the two variables of primary interest: mark-ups and pass-through. Those figures plot these differences as a function of the number of firms which exit in the new economy. A positive difference indicates that the variable is higher in the new economy than in the symmetric Nash economy. Figure 11 shows the results in Table 1 for a change in the number of firms. Figures 12 and 13 illustrate the analytical results presented in Propositions 1 and 2 respectively. Taken together, these figures demonstrate our earlier conclusion that the first three types of restructuring (exit, entry by a cost leader, and entry by a quantity leader) are not consistent with both lower mark-ups and lower pass-through. Figure 14 indicates that if there is enough exit in the Stackelberg economy with cost asymmetries, then both pass-through and mark-ups can be lower than in the symmetric Nash economy.

Figures 15-17 present the same variables but with asymmetric cost elasticities. Figure 17 demonstrates that mark-ups and pass-through can both be lower in the new economy even when the number of firms does not change if the leader's costs are less responsive to exchange rate movements. This case may most closely represent the shifts in Canadian retailing due to the entry and expansion of big-box retailers in Canada. Retailers such as Wal-Mart may act as industry Stackelberg leaders. Furthermore, because of their size and industry position, they have lower production costs due to increasing returns and can effectively bargain with wholesalers and importers for lower costs and less exposure to exchange rate movements. Smaller (perhaps independent) retailers may act as industry followers, may have higher costs, and more exposure to exchange rate volatility. If we imagine that these firms were in operation before the expansion of big-box retailers, then those firms who do not exit in the aftermath, will perceive the industry as more competitive because mark-ups will be lower. Because of these shifts in the market structure of the industry, prices will be less responsive to exchange rate movements.

9 Conclusions and Extensions

This paper has explored two potential explanations for the observed decline in exchange rate pass-through to consumer prices in Canada over the last two decades: a fall in inflation and restructuring in the retail industry. These explanations should not be thought of as competing, but rather as connected. The restructuring in Canadian retail which apparently has increased competition in that sector may have reduced firms' pricing power and contributed to low inflation. Conversely, shifts in monetary policy toward lower inflation may have altered consumer behaviour and may have changed the competitive environment in the retail sector. These forces together have lowered retailers' ability and willingness to pass-through exchange rate movements to their prices.

More work is needed to document the trends in mark-ups in Canadian retailing because the key to a better understanding of pass-through is a better understanding of the response of mark-ups to movements in exchange rates. Future research on exchange rate pass-through should focus more on microeconomic models of strategic price setting behavior in dynamic, stochastic general equilibrium environments. Our discussion of the relationship between inflation and exchange rate pass-through suggests that we also might think more carefully about how the inflationary environment affects firm behaviour *and* consumer behaviour.

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[37] Taylor, John B. (2000), "Low Inflation, Pass-Through, and the Pricing Power of Firms," *European Economic Review* 44: 1389-1408. Note that $\hat{C}_s \leq 1$ under CRS and that if there are no domestic inputs, then $\hat{C}_s = 1$. We wish to re

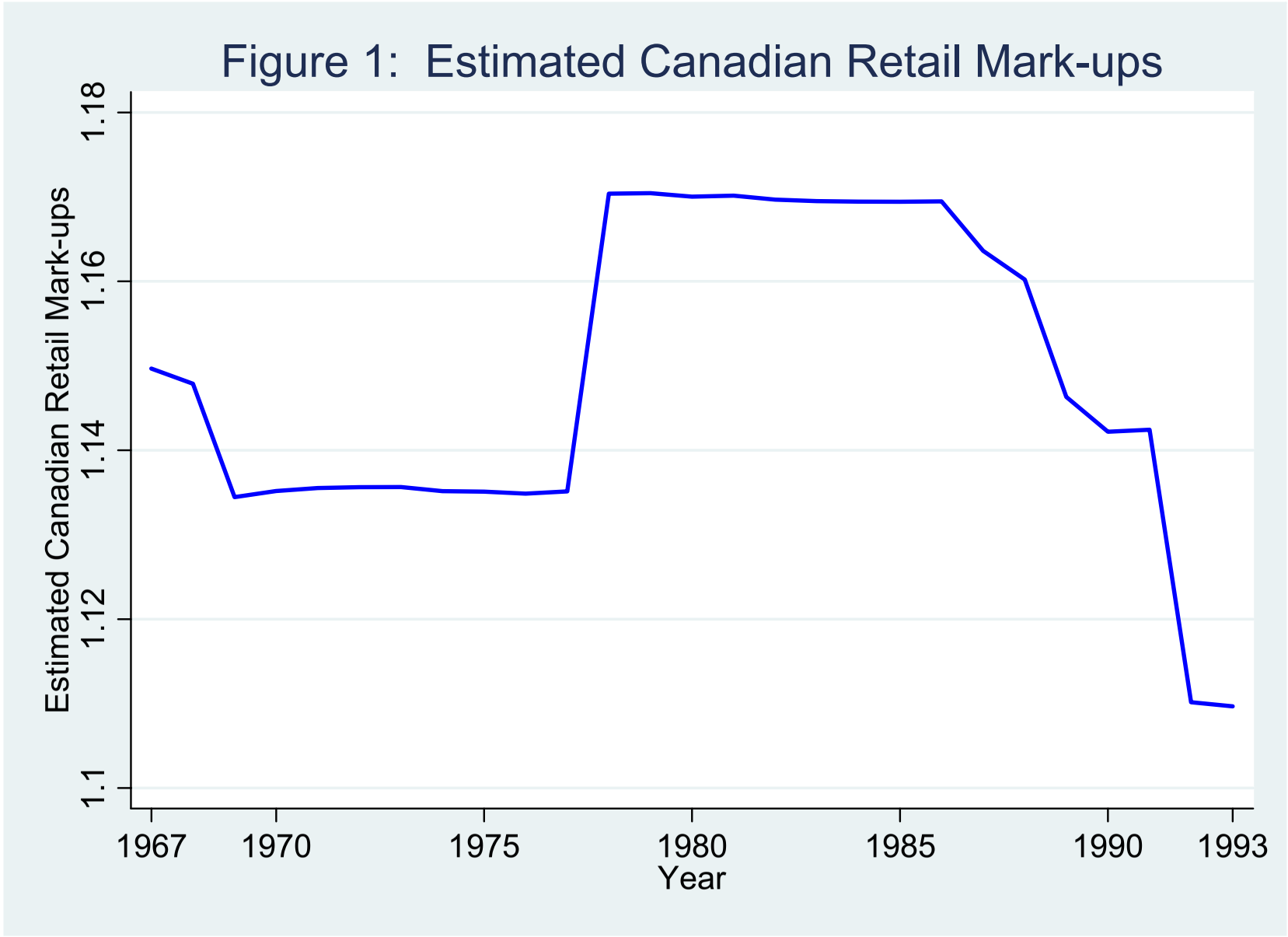
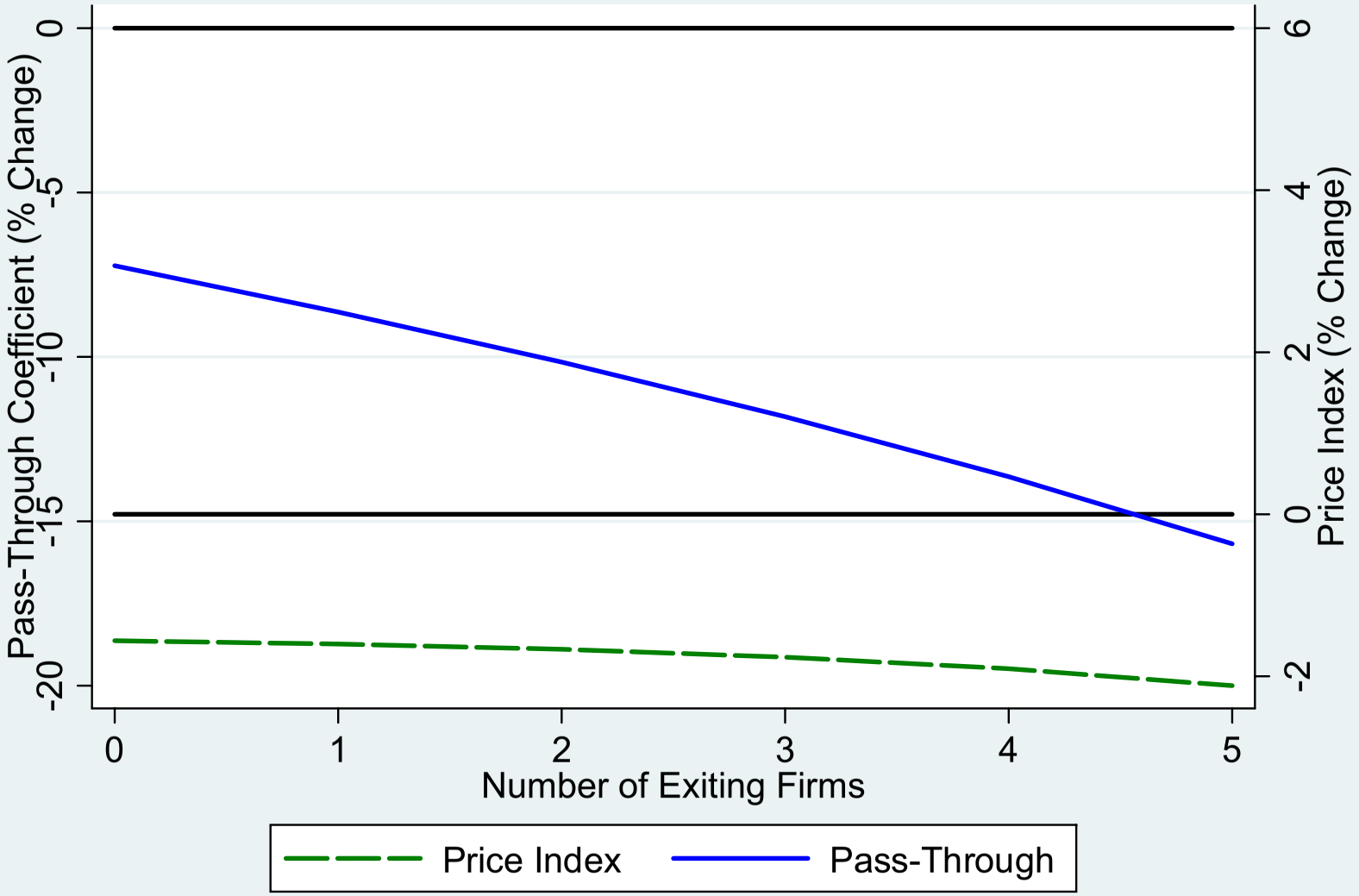


Figure 1: Estimated Canadian Retail Mark-ups
Estimated Canadian Retail Mark-ups
1.1
1.12
1.14
1.16
1.18
1967
1970
1975
1980
1985
1990
1993
Year

Figure 2: Asymmetric Nash -- Prices and Pass-Through



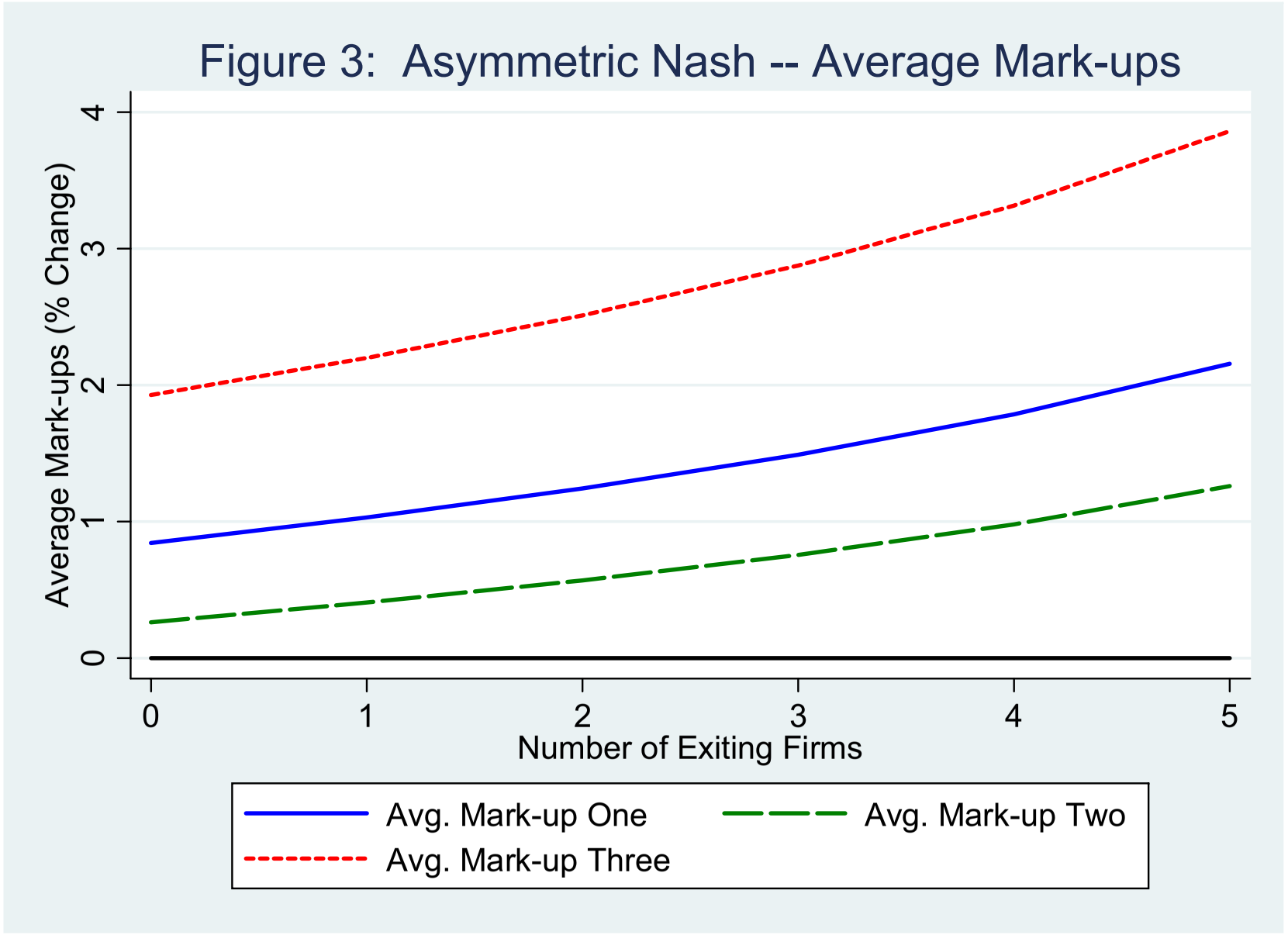


Figure 3: Asymmetric Nash -- Average Mark-ups
Average Mark-ups (% Change)
0
1
2
3
4
0
1
2
3
4
5
Number of Exiting Firms
Avg. Mark-up One
Avg. Mark-up Two
Avg. Mark-up Three

Figure 4: Asymmetric Nash -- Firm Mark-ups

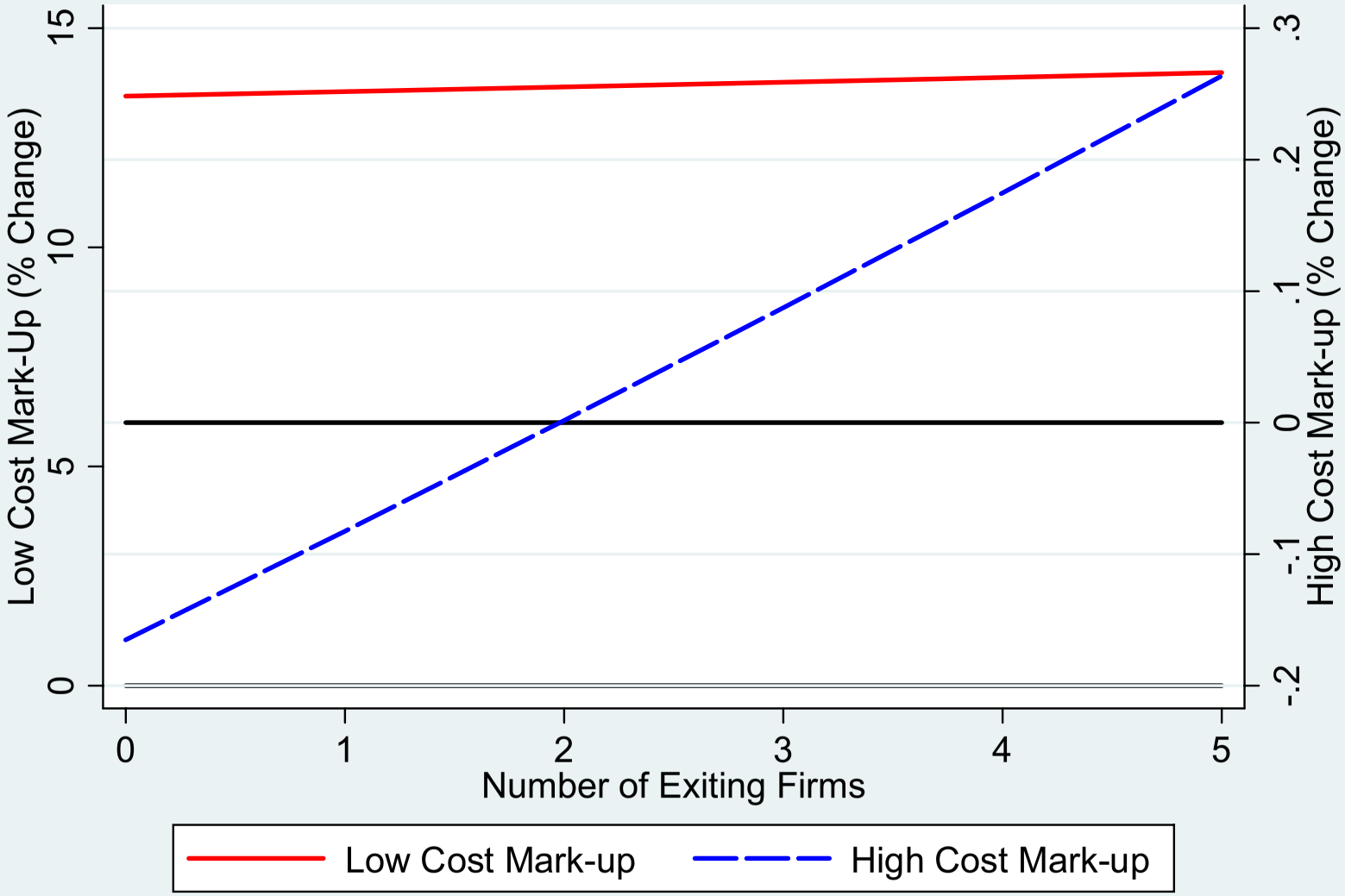
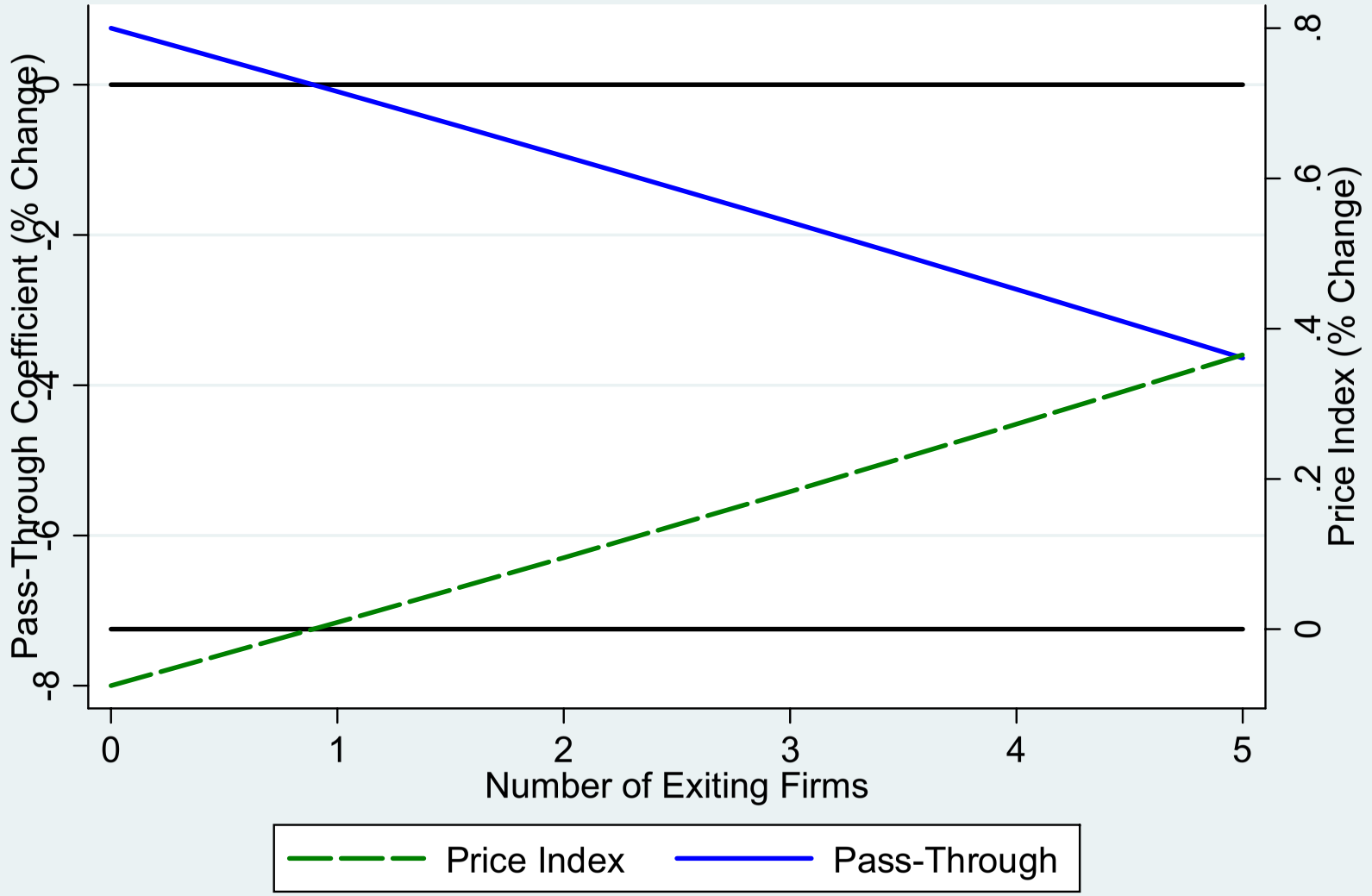


Figure 5: Symmetric Stackelberg -- Prices and Pass-Through



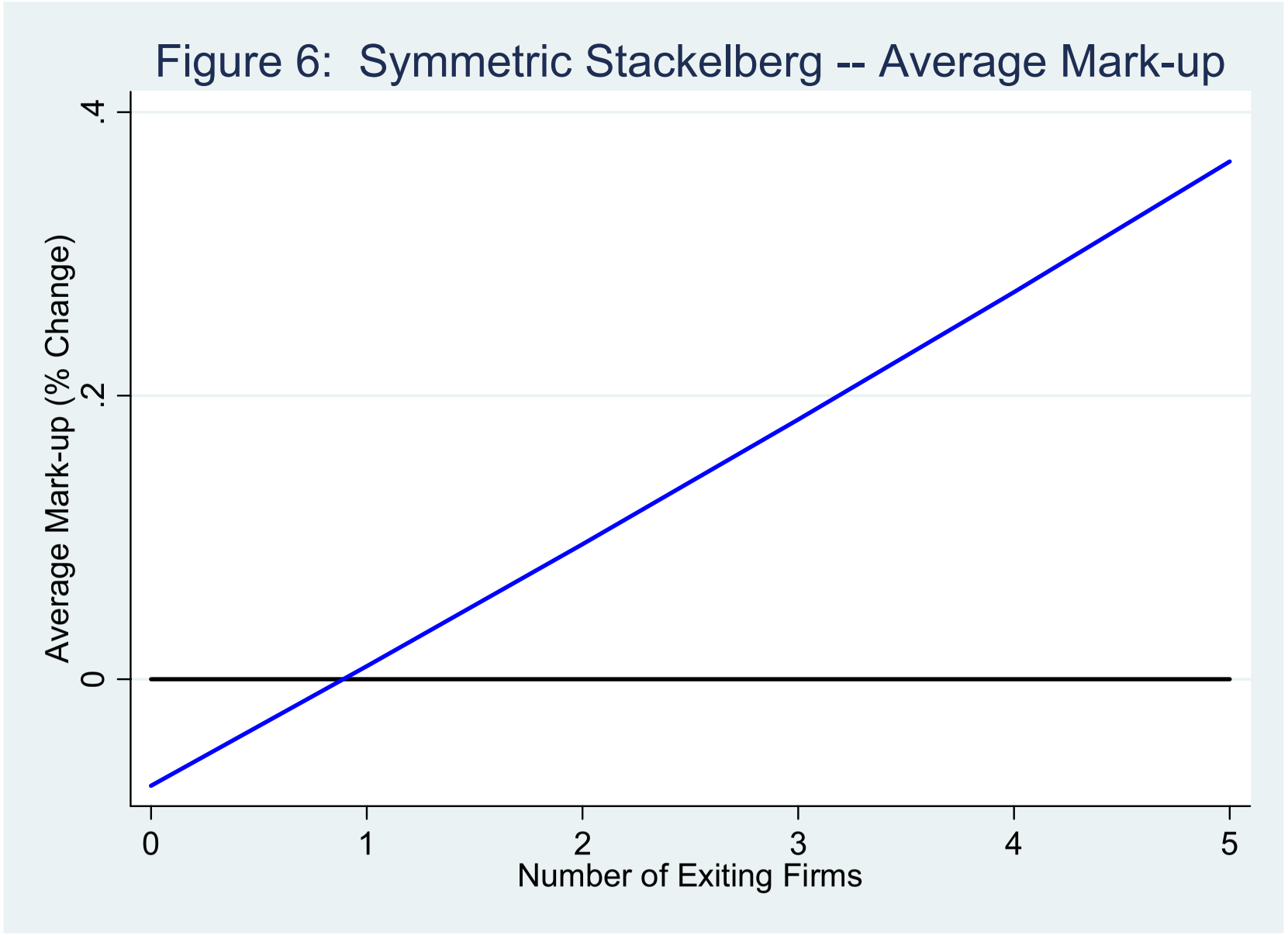


Figure 6: Symmetric Stackelberg -- Average Mark-up
Average Mark-up (% Change)
0
.2
.4
0
1
2
3
4
5
Number of Exiting Firms

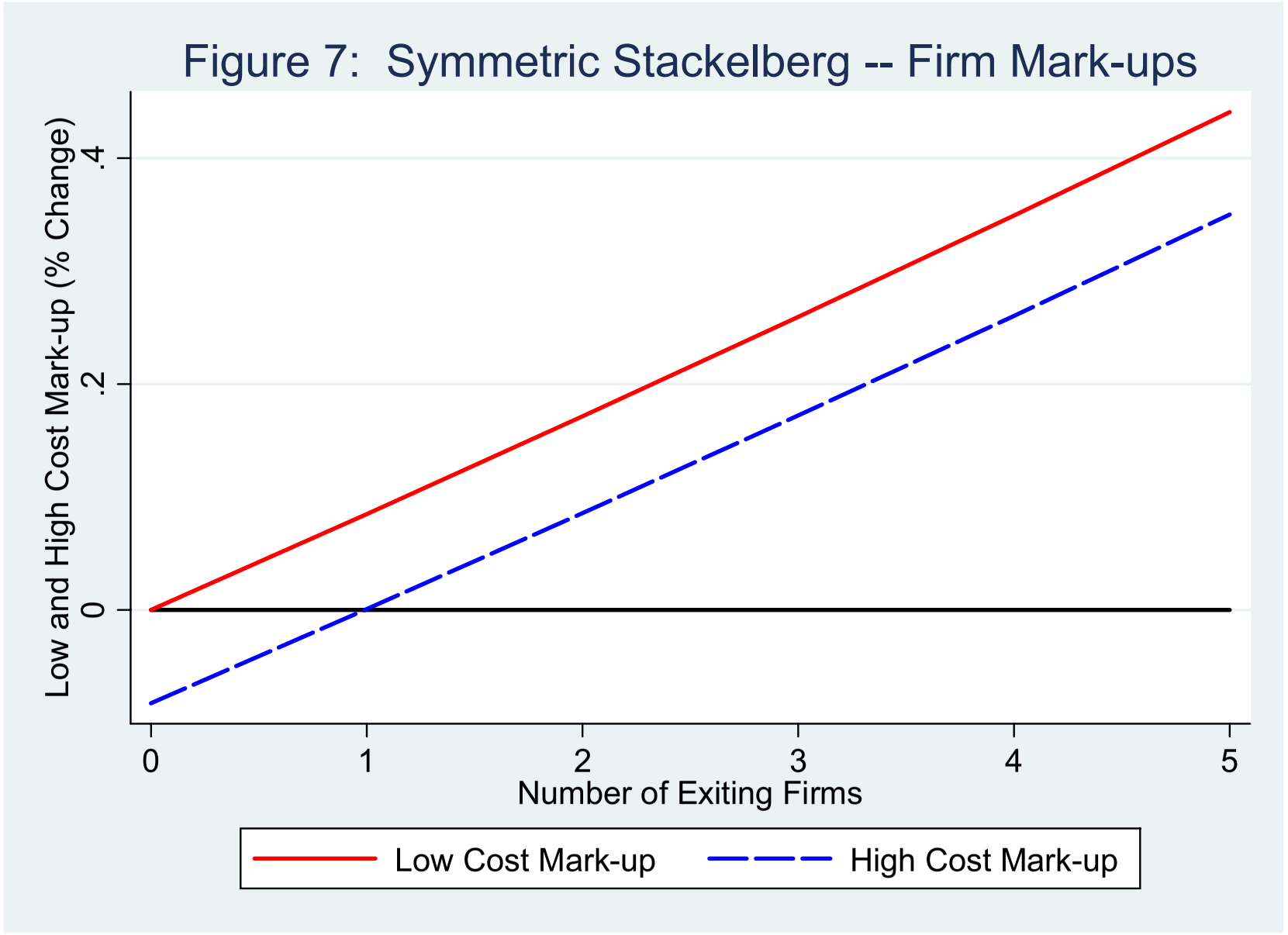
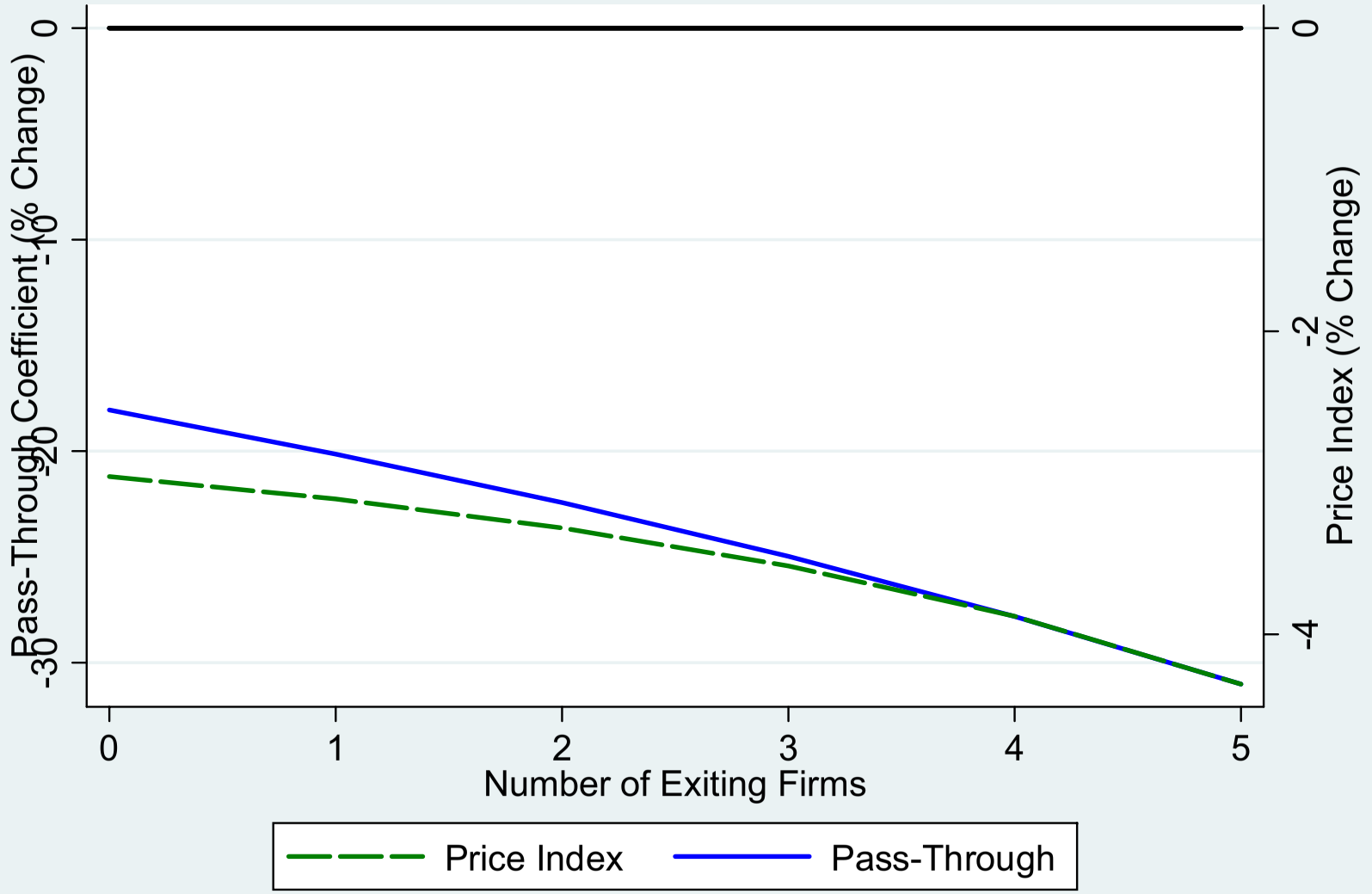


Figure 7: Symmetric Stackelberg -- Firm Mark-ups
Low and High Cost Mark-up (% Change)
0
.2
.4
0
1
2
3
4
5
Number of Exiting Firms
Low Cost Mark-up
High Cost Mark-up

Figure 8: Asymmetric Stackelberg -- Prices and Pass-Through



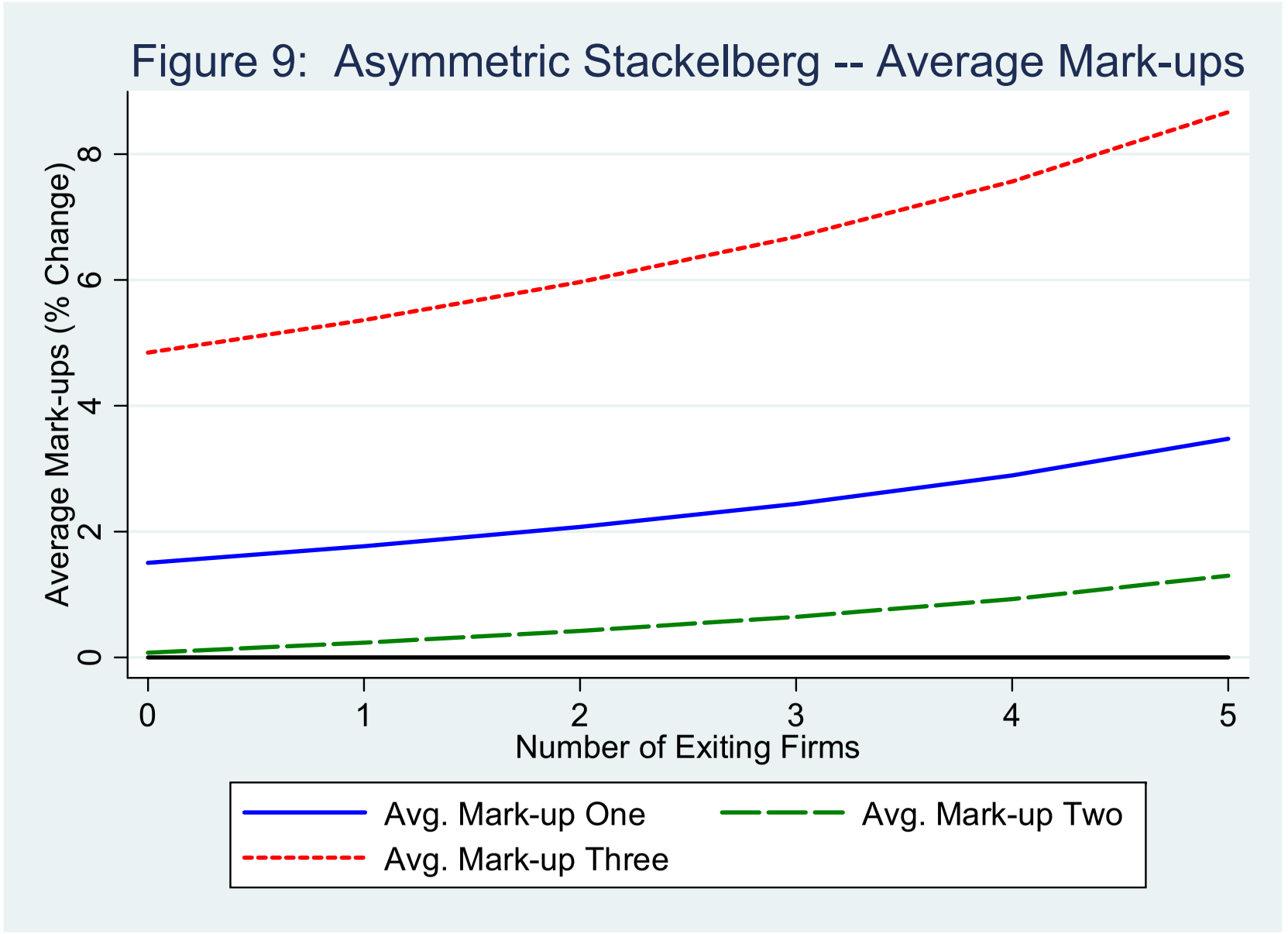


Figure 9: Asymmetric Stackelberg -- Average Mark-ups
Average Mark-ups (% Change)
0
2
4
6
8
0
1
2
3
4
5
Number of Exiting Firms
Avg. Mark-up One
Avg. Mark-up Two
Avg. Mark-up Three

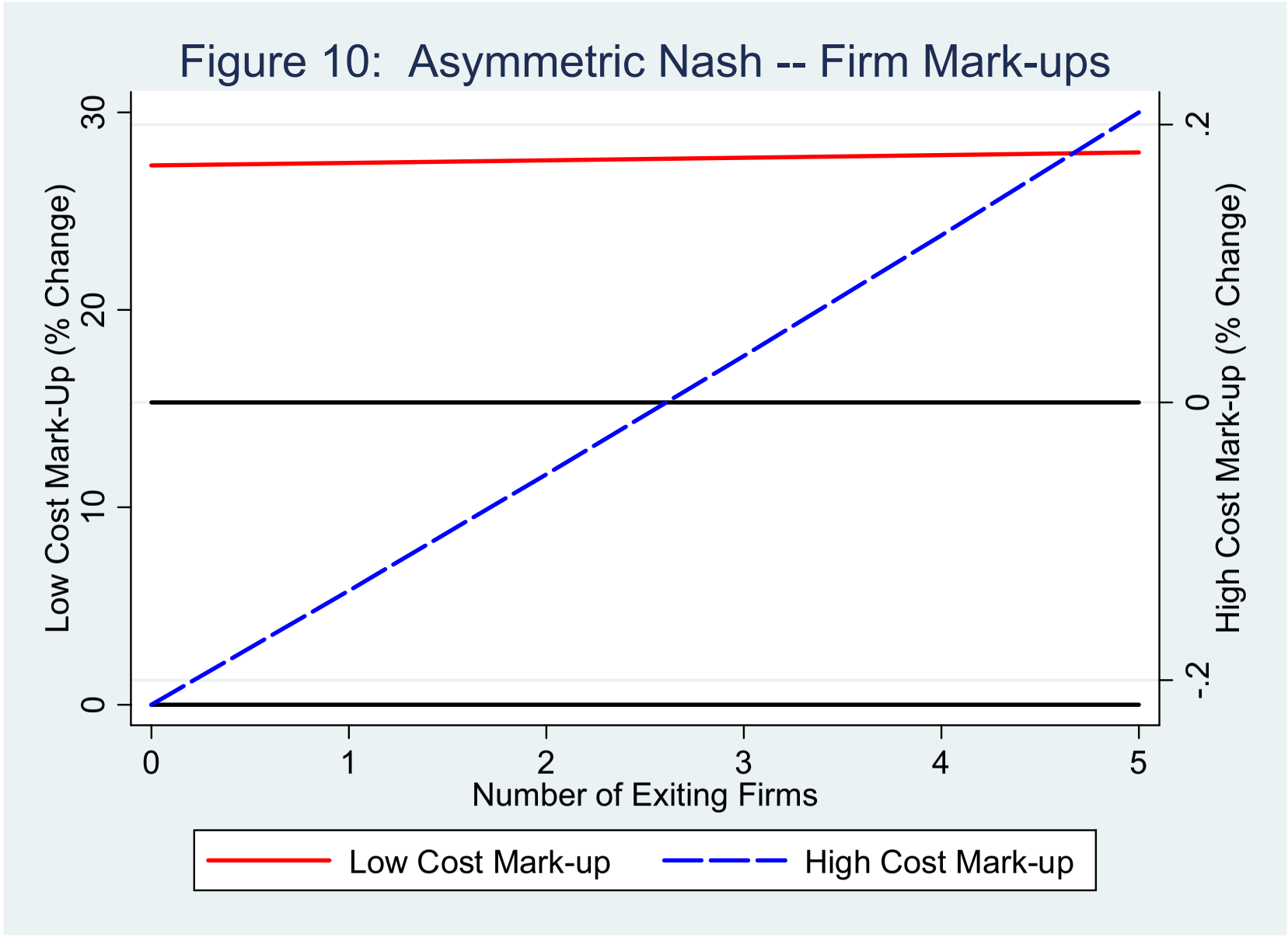


Figure 10: Asymmetric Nash -- Firm Mark-ups
Low Cost Mark-Up (% Change)
0
10
20
30
High Cost Mark-up (% Change)
-.2
0
.2
0
1
2
3
4
5
Number of Exiting Firms
Low Cost Mark-up
High Cost Mark-up

Figure 11: Symmetric Nash -- Mark-ups and Pass-Through

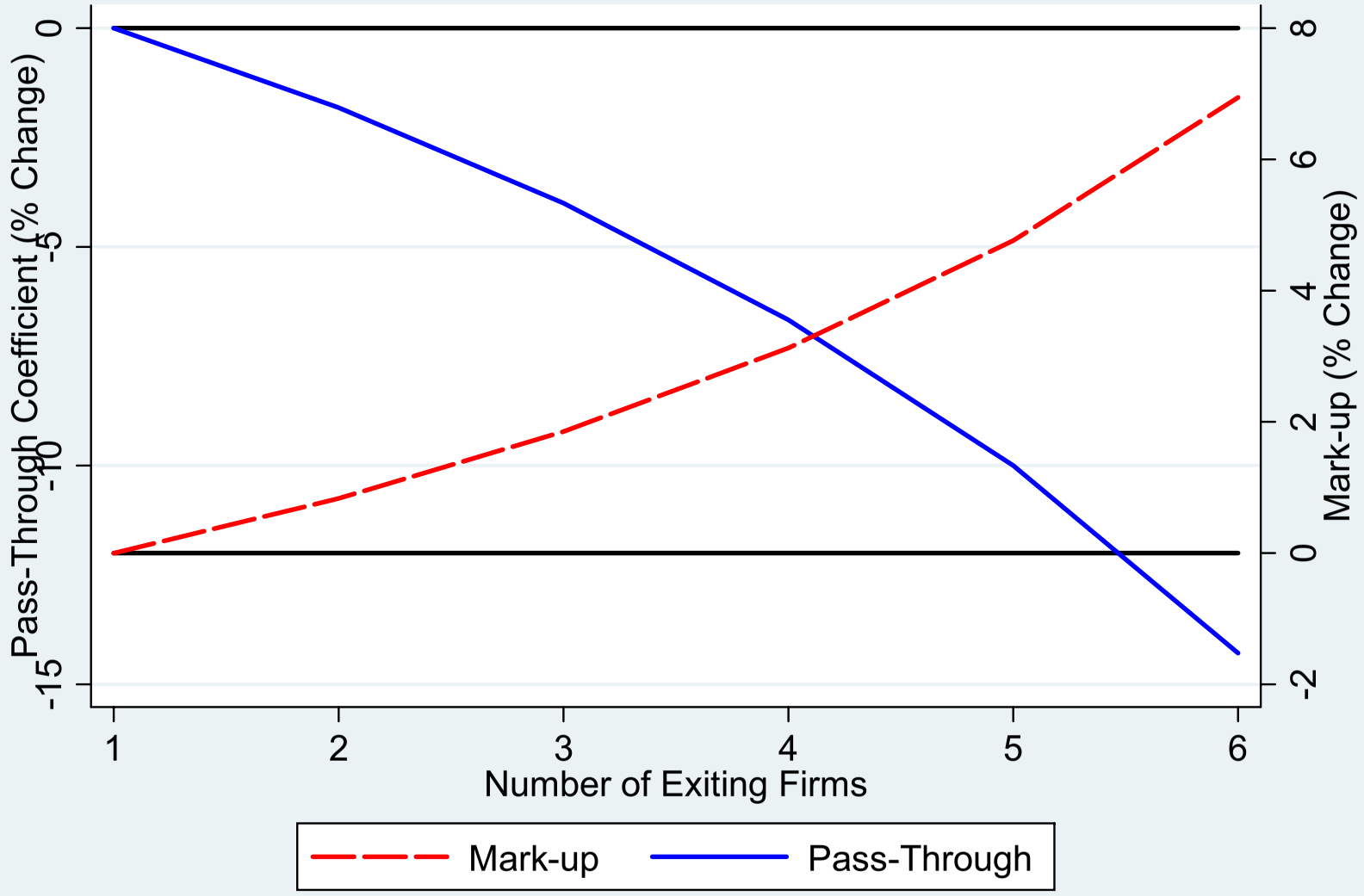


Figure 12: Asymmetric Nash -- Mark-ups and Pass-Through

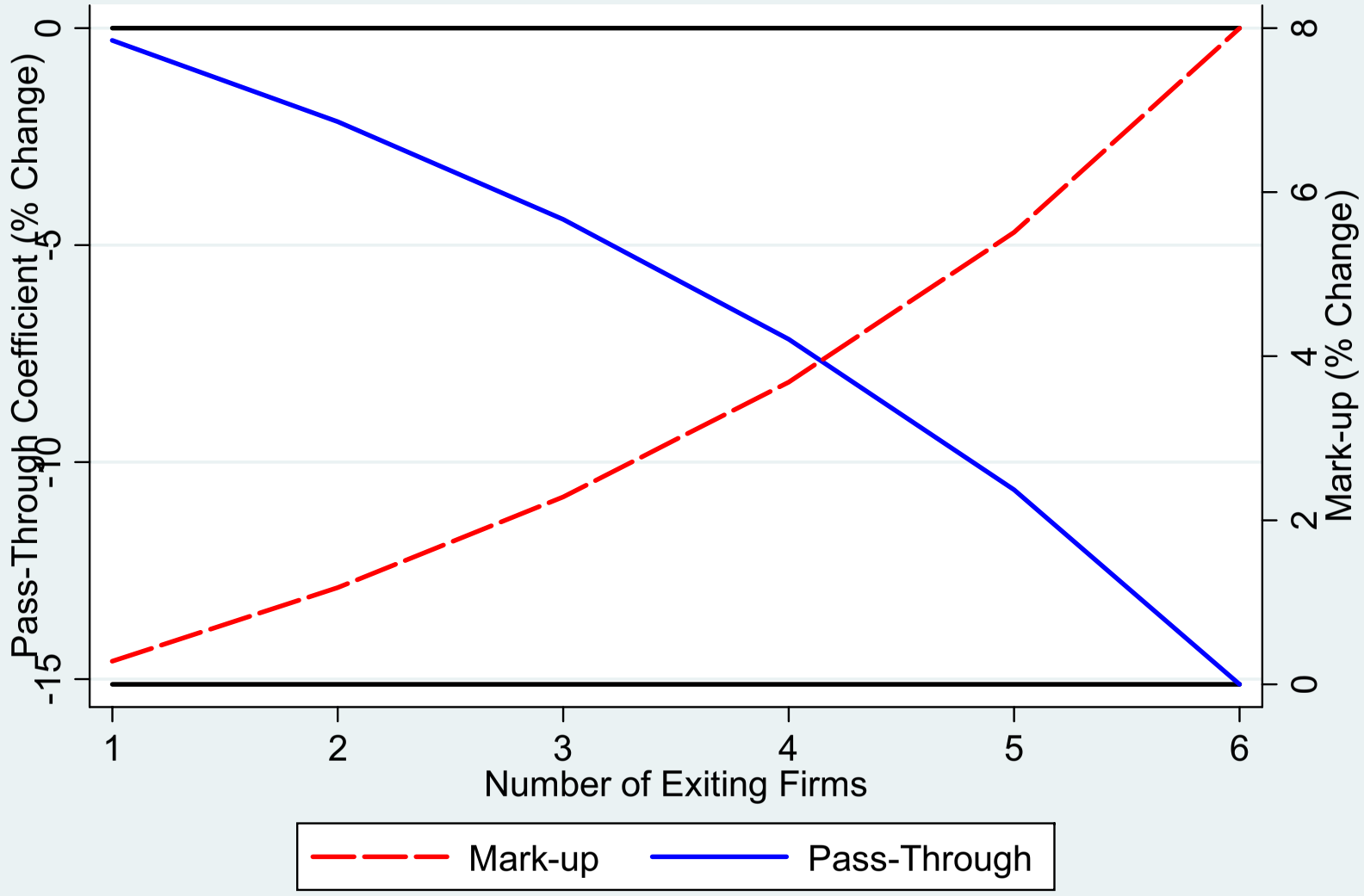


Figure 13: Symmetric Stackelberg -- Mark-ups and Pass-Through

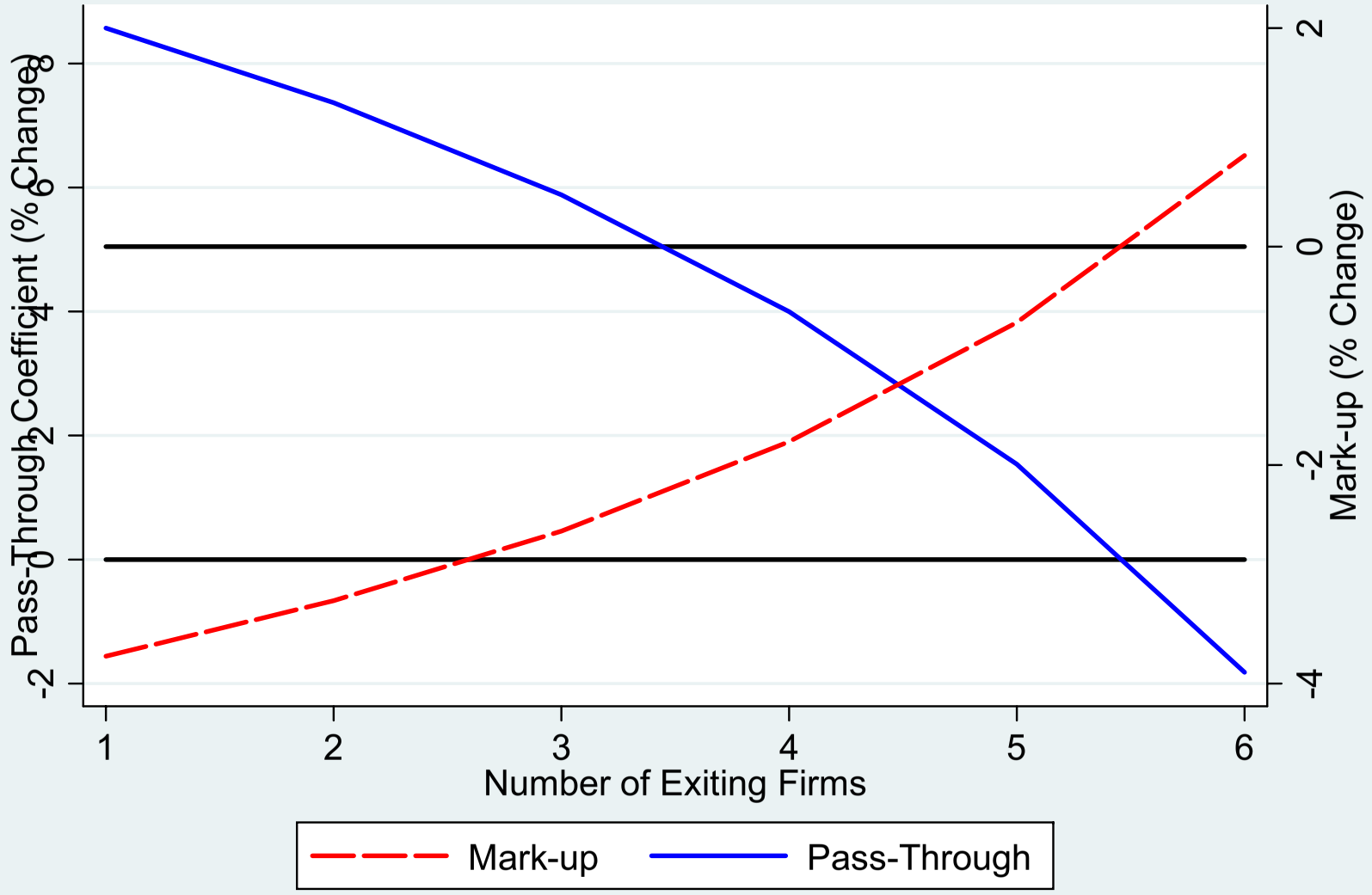


Figure 14: Asymmetric Stackelberg -- Mark-ups and Pass-Through

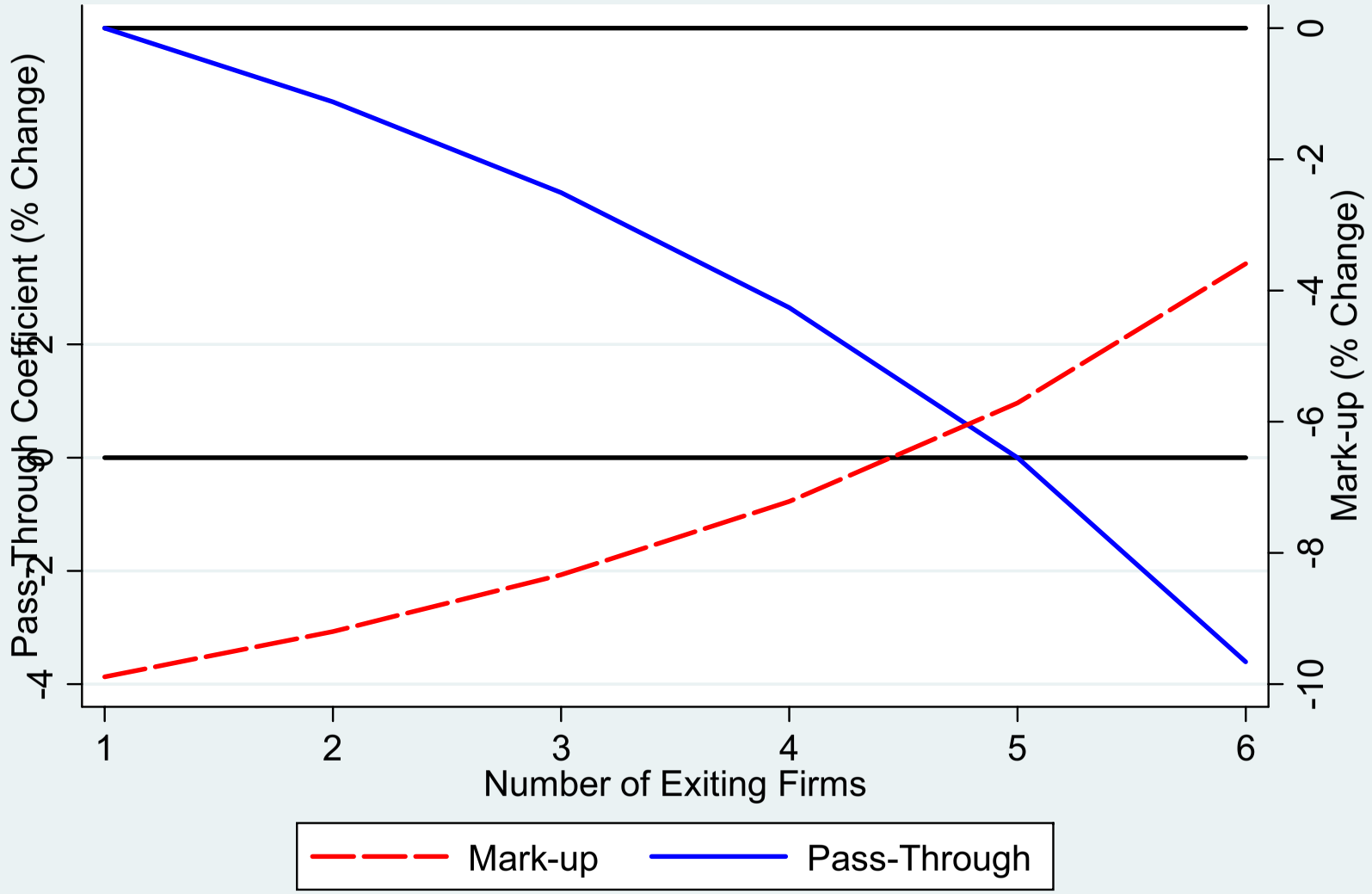


Figure 15: Asymmetric Nash with Asymmetric Cost Elasticities

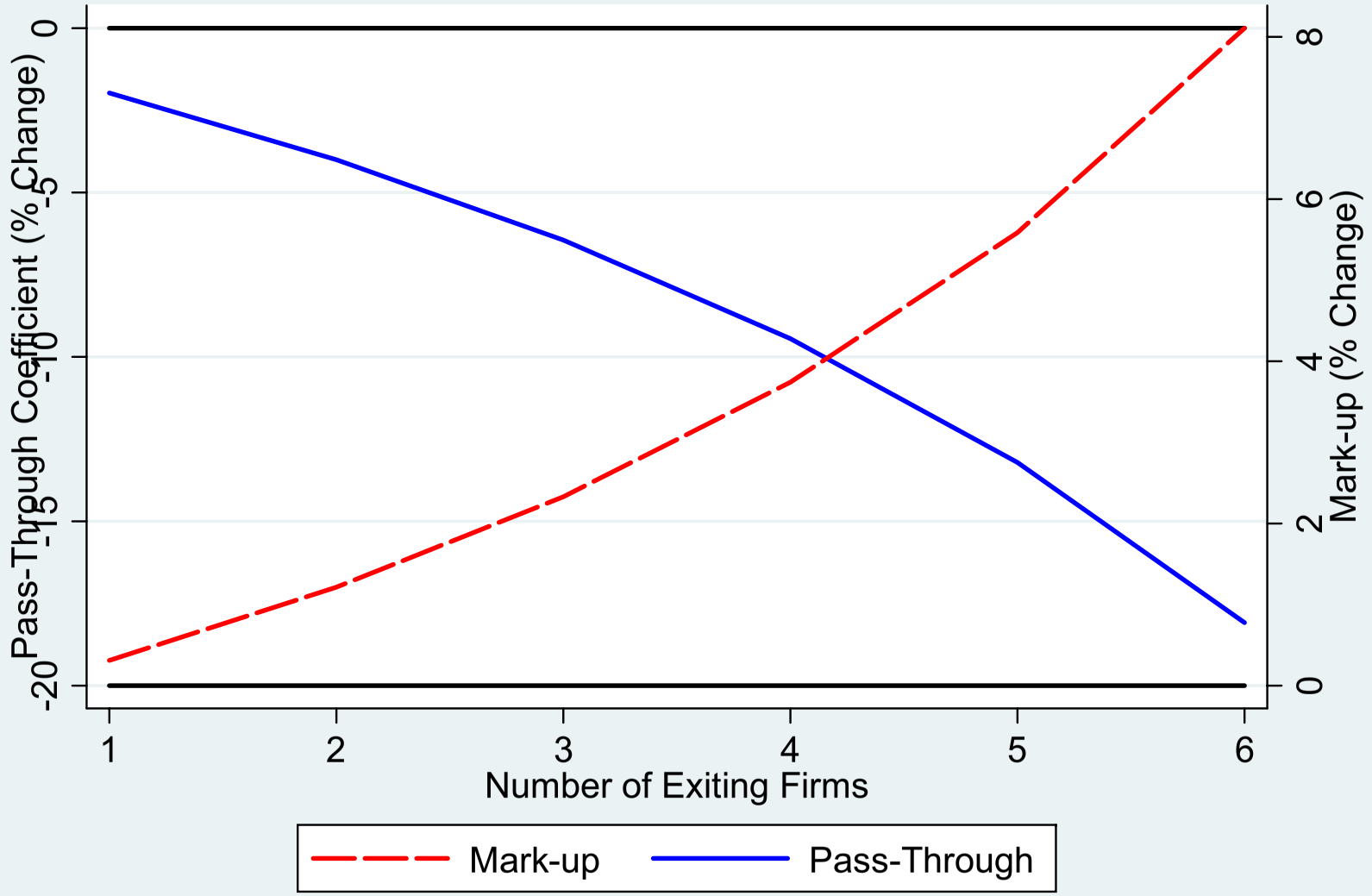


Figure 16: Symmetric Stackelberg with Asymmetric Cost Elasticities

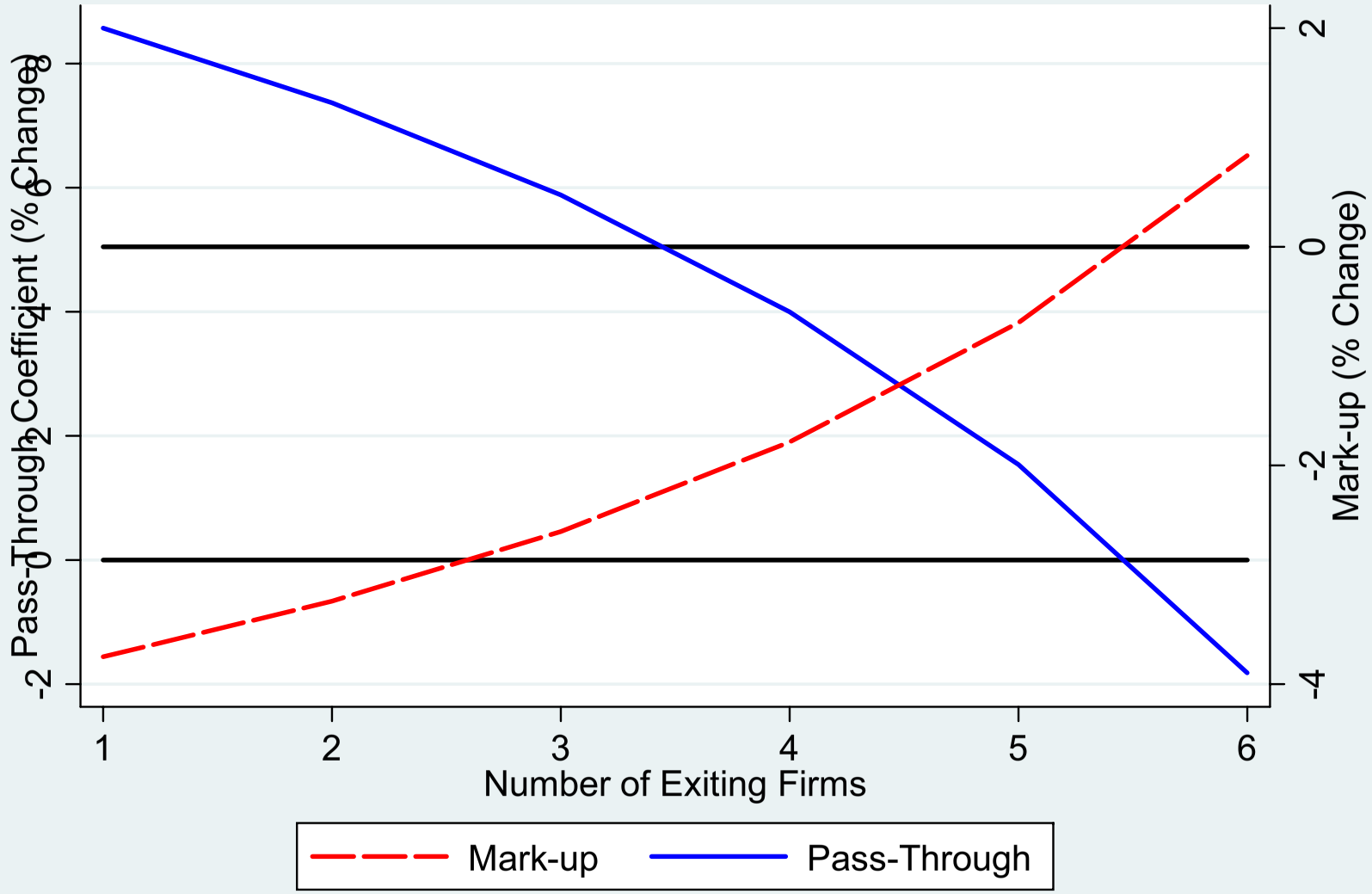
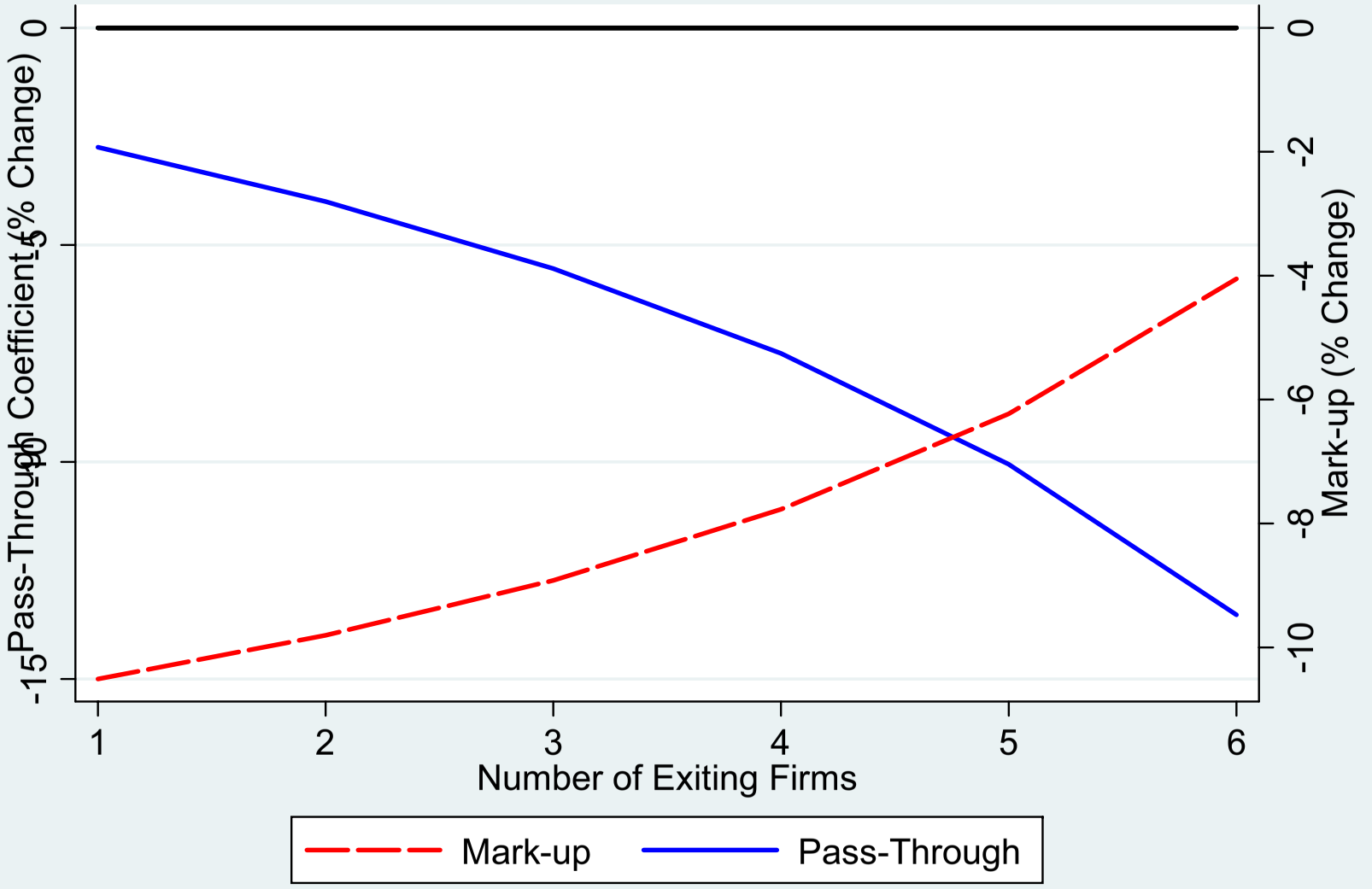


Figure 17: Asymmetric Stackelberg with Asymmetric Cost Elasticities



10 Appendix 2: Demand Examples in Homogeneous Product Model

10.1 *Cobb-Douglas Utility*

Suppose utility is defined over the good of interest and the outside good and is given by

$$U(C, C^o) = C^{o\gamma} C^{1-\gamma}.$$

In this case, we have the following demand function

$$C = \frac{(1-\gamma)E}{P},$$

and the following elasticities:

$$\epsilon = 1 \qquad \phi = 0 \qquad \psi = 0.$$

In symmetric Cournot, we have

$$P^* = \frac{nc}{n-1} \qquad \hat{P}_s^* = \hat{c}_s$$

So here, pass-through is less than one if and only if there are domestic inputs. Furthermore, a fall in the number of firms raises concentration and the mark-up but has no effect on pass-through

10.2 *Leontief Utility*

Suppose utility is defined over the good of interest and the outside good and is given by

$$U(C^0, C) = min\left\{\frac{C^0}{\gamma^0}, \frac{C}{\gamma}\right\}$$

Let $\gamma^0 P^0 + \gamma P \equiv z$, then

$$C = \frac{\gamma E}{z}$$

and

$$\epsilon = \frac{\gamma P}{z} \qquad \phi = \frac{\gamma^0 P^0}{z} \qquad \psi = \frac{-\gamma P}{z}$$

Note that $\phi > 0$ so pass-through is less than one even when there are no domestic inputs and $n\epsilon + \psi > 0$ so pass-through is increasing in the number of firms. Hence a fall in the number of firms increases concentration and mark-ups and decreases pass-through.

10.3 *Constant-Elasticity of Substitution Utility: Two Goods*

Suppose utility is defined over the good of interest and the outside good and is given by

$$U(C, C^o) = \left[C^{0\gamma} + C^{\gamma}\right]^{\frac{1}{\gamma}},$$

with $\gamma < 1$. Let $z \equiv (P/P^0)^{\frac{\gamma}{1-\gamma}}$, then we have

$$C = \frac{E}{(z+1)P},$$

and the following elasticities:

$$\epsilon = \frac{1+z-\gamma}{(1-\gamma)(1+z)} \qquad \phi = \frac{\gamma^2 z}{(1-\gamma)(1+z)(1+z-\gamma)}$$

$$\psi = \frac{\gamma(1-z^2-\gamma)}{(1-\gamma)(1+z)(1+z-\gamma)}$$

Now $\phi > 0$ so pass-through is less than one in all cases. Furthermore, we have $n\epsilon + \psi = (n-1)\epsilon + (\epsilon + \psi)$, and we can show that

$$\epsilon + \psi = \frac{1+z}{1+z-\gamma},$$

which is positive. Hence, pass-through falls when the number of firms falls, while concentration and the mark-up rise.

10.4 *Constant-Elasticity of Substitution Utility: Many Goods*

Suppose utility is defined over the good of interest and many other goods as a constant-elasticity-of-substitution function as follows:

$$U(C, C^1, C^2, \ldots, C^n) = \left[C^{\gamma} + \sum_{j=1}^{n} C^{j\gamma}\right]^{\frac{1}{\gamma}},$$

with $\gamma < 1$. Under the assumption that n is large, each firms perceived elasticity of demand is

$$\epsilon = \frac{1}{\gamma - 1}$$

with

$$\psi = 0.$$

In this case, then pass-through of the exchange rate equals the pass-through of exchange rates to costs:

$$\hat{P}_s^* = \hat{c}_s.$$

Hence, the mark-up and pass-through are unaffected by a change in the number of firms in the industry. This is a common specification of models with nominal rigidities where incomplete pass-through of costs is all generated through nominal rigidities.