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Political Risk and Irreversible Investment

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Abstract

The objective of this paper is twofold. First, we develop a theoretical model to investigate the impact of political risk on irreversible investment. Second, we apply our model to an analysis of the effects of risk of separation of the province of Quebec from the Canadian federation. We model the probability of a regime switch using the properties of the electoral process and examine the response of investment to changes in the risk of separation. We consider the impact of investors' perception of the risk of separation and financial market volatility separately. We show that political risk has a depressing impact on investment even if the "bad " regime has never been observed in the sample.

Keywords: Irreversible investment, political risk, regime shifts, Quebec investment, Canada

JEL Codes: E22, D92, O16, O11.

1 Introduction

In emerging and developing economies investors are often faced with political risk due to the risk of expropriation, disruptions in market access, unfavorable government regulations, currency, debt and fiscal crises, policy reversals, political upheaval, etc... Investors in developed economies are also exposed as the debates on outsourcing reveal. Yet there has been little work in quantifying the effect of political risk on real investment decisions.

A literature has examined the impact of political risk on foreign direct investment (FDI) flows and capital flight. In his provocative article, Lucas (1990) lists political risk as one of the factors behind the puzzling lack of capital flows from rich to poor countries. Svensson (1998) argues that the lack of political stability leads to lower investment because political instability impedes the incentive to create an efficient system of property rights. Lensink, Hermes and Murinde (2000) find that after controlling for macroeconomic and policy variables, political risk stimulates the magnitude of capital flight. Janeba (2002) considers the investment decisions of a multinational firm in a politically risky world and emphasizes the trade-off between lack of credibility and low cost in the determination of FDI decisions. In a different vein, Kim and Wei (2001) study the impact of political news on stock market volatility for the Hong Kong stock market while Lobo (1999) finds that U.S. stock returns responds differently to the type of election and to the party of the administration in power. Political risk regarding the future of European Monetary Union is also widely perceived as affecting the behavior of financial markets. Remolona, Wickens, and Gong (1998) find that the real risk premium on U.K. bonds fluctuated considerably since the exit from the ERM, reflecting uncertainty about the real economy.

There is also a growing literature that studies the economic effects of political integration

and separation. According to one view, as economic integration increases, the political costs of separation may decrease. This view is expounded by Alesina, Spolaore and Wacziarg (2000, 2004), who examine the relation between openness in trade and the equilibrium number and size of countries. They find that the economic benefits of country size are mitigated by the degree of openness to trade, and also that the history of the creation of nation-states depends on the trade regime. An alternative view suggests that political separation would lead to a change of political constituency. Hence, the policy of a seceding country would be determined by the citizens of that country alone. Braun, Hausmann, and Pritchett (2004) show that political disintegration has ambiguous effects on the quality of policies and negative effects on economic growth because it reduces economic market size. The role of political stability and economic integration in fostering trade has been stressed by McCallum (1995), Helliwell (1995) and Anderson (2001). Using a theoretically well grounded gravity model Anderson (2001) finds that trade between Canada and the US is lowered by 45% due to the modest border between the two countries. Trade among Canadian provinces is six times larger, while trade among US states is 25% larger thus indicating that for a small country the border effect is quantitatively more important.

The objective of this paper is twofold. First, we develop a theoretical model to investigate the impact of political risk on irreversible investment. Second, we apply our model to an analysis of the risk of separation of the province of Quebec from the Canadian federation on Quebec investment. The case study of Quebec provides for a unique "natural experiment" of the impact of political risk in a developed economy. The issue has existed for almost fifty years and the data are of high quality. Two episodes of political risk are clearly identifiable: the 1970's and the 1990's. In this paper, we seek to determine the quantitative

impact of the risk of separation on Quebec investment for the second episode of political risk, namely the 1990's.

As a way of modelling the presence of political risk, we allow for regime switches between a "good" regime and a "bad" regime (separation), where the former is characterized by more "favorable" distributions for the state of demand or productivity. While the firm knows which regime it is currently residing in, each period it must assess the transition probabilities on the basis of a vector of economic and political variables. We introduce an electoral process whereby a federalist party (L) and a separatist party (PQ) compete for power. When the latter is elected it may hold a referendum on separation and a switch to the "bad" regime becomes possible.

The arguments in the recent literature provide some justification for modelling political risk in this way. Despite the countervailing arguments regarding the role of increased economic integration on the impact of separation or secession, one of the major impacts of separation appears to lie in the reduction in trade and market access due to the erection of borders between Quebec and the rest of Canada. More specifically, in the event of separation, firms in Quebec would expect: (1) reduced market access to the rest of Canada due to the passage from a highly integrated economic union in the Canadian federation to a looser form of economic union such as a customs union; (2) reduced short-run and possibly long-run access to NAFTA partners' markets ; (3) loss of the monetary union with the rest of Canada; (4) a high debt to GDP ratio as Quebec would have to pay its share of the federal debt. Firms would also expect a higher long-term risk premium. Therefore, even in the absence of a crisis, at least a recession would be expected.

Separation could also lead to the expectation of a crisis, or "sudden stop" phenomenon

whereby much higher interest rates and a more severe loss of output and productivity would be expected following separation. Such a situation might occur if the rest of Canada were to refuse to negotiate or that negotiations were to prove arduous. In 1995, the Quebec referendum question stipulated that failing an agreement with the rest of Canada, Quebec would proceed with a unilateral declaration of independence (UDI). However, a UDI would provoke a conflict of legitimacy (since the electorate is highly divided). There would be massive capital flight leading to a banking crisis as individuals would expect that a separate Quebec would attempt to create a Quebec dollar in order to devalue. The analogy to the Mexican (1994), Argentinian (2001) and the East Asian crises is immediate. Since the Quebec economy is highly sophisticated, financial capital is highly mobile, and the amplitude of the crisis could be even greater.

Our analysis is based on the profit-maximization model of a risk neutral representative monopolistically competitive firm under uncertainty and irreversibility. The firm-specific or industry-specific nature of most investment goods implies that investment decisions are, at least largely, irreversible, and therefore more sensitive to uncertainty due to an option value of waiting, or to an endogenous risk premium.[1] The experience in Quebec features declines in investment together with increases in financial volatility. We argue that these events are consistent with the presence of political risk as being responsible for the decline in investment in Quebec. Bittlingmayer (1998) presents a similar argument for Germany in its transition from Empire to the Weimar Republic. As in our analysis, he attributes this phenomenon to the "bad news" principle and the option value of waiting in models with investment irreversibility under uncertainty. In our framework, the perceived threat

[1]For a discussion of the literature, see the recent survey by Demers, Demers, and Altug (2003), Hassett and Hubbard (2002), Caballero (1999) and Dixit and Pindyck (1994).

of separation can affect investment in two ways. The first is what we call the *political risk* channel. According to this channel, it is the perceived likelihood of transiting to a regime with less favorable fundamentals that is responsible for the decline in investment. The second is directly through increases in real interest rates or the stochastic discount factor firms use to discount future cash flows. We call this the *financial market* effect of political risk.

Our quantitative analysis proceeds in several parts. First, we analyze the public's perceptions of political risk using data on poll/election/referendum results and financial market variables. Second, we use annual sectoral data on investment and capital stocks to provide a simple test of the impact on political risk on investment behavior. For this purpose, we take Ontario as a point of comparison, and show that the investment-capital stock ratios in machinery and equipment investment for all broadly defined sectors of the economy were significantly lower in Quebec during the second period of political risk. Third, we conduct a simulation exercise to examine the impact of political risk on investment behavior. Our approach to simulating the model is to ask what must investors' perceptions for fundamentals in a likely separation state be so that the model can generate the observed declines in investment. This is similar to the reverse calibration that Danthine and Donaldson (1999) implement in their application.[2]

The paper is organized as follows. Section 2 discusses political risk in the context of Quebec. Section 3 describes the model. Section 4 describes the quantitative impact of regime shifts and an absorbing state on investment, and discusses the role of stochastic interest rates. Some concluding remarks are in Section 5.

[2]See also Weitzman (2005).

2 A Case Study of Quebec

2.1 A brief historical perspective

Two major episodes of political risk have had an important impact on the Quebec economy, and particularly, on Quebec investment. The first is that of the 1970s, marked by the provincial election in 1976 of a separatist party, the Parti Québécois (PQ). When the PQ finally held its referendum in 1980, it was defeated, with 60% of the voters being opposed to giving a mandate to the Quebec government to negotiate "sovereignty-association"[3] with the rest of Canada. The defeat of the PQ in the referendum led to a period of political calm in the 1980's. The PQ was re-elected in 1981, but only after shelving its sovereignty plans. Subsequently, it was defeated in December 1985 by its federalist opponent.

The second episode of political risk is that of the 1990s, marked by the federal government's failed attempts at constitutional reform (the "Meech Lake Accord"), which led to a rise in popularity of the separatist option in Quebec (see Table 1), the subsequent election of the PQ in 1994, and another referendum on sovereignty with a "European style" partnership very narrowly lost by the PQ in 1995.[4] The margin of 0.8% encouraged separatist

[3]The referendum question did not ask directly for support on independence, but rather asked for support on "sovereignty" together with a form of association with the rest of Canada. What is notable is that the form of the association in question and the degree of autonomy that was sought were not clearly defined. The question was intentionally ambiguous to garner the maximum of support, but the PQ lost the referendum nevertheless.

[4]As in the 1980 referendum, the referendum question did not ask directly for support on independence, but asked for support on a "partnership proposal" with the rest of Canada taking the European Union (EU) as a model. As in 1980, there was no tangible evidence that the rest of Canada would agree to any form of association other than the currently existing federal form. See Demers and Demers (1995) for a discussion as to why the EU model is not a viable option for the case of Quebec-Canada. The referendum question

leaders to promise another referendum which maintained uncertainty until the 1998 provincial elections when the federalists succeeded in obtaining more votes than the PQ although the latter managed to obtain more seats in the legislature and to form the government. As a result, the PQ temporarily abandoned its plans for another referendum.[5]

2.2 Perceptions of political risk: poll results and financial market data

What do Quebecers and financial markets think about the likelihood of separation of Quebec from the Canadian federation? While there is no direct observation of this perception, we look at some indicators such as opinion polls, election and referendum results as well as financial market data such as bond spreads.

In Table 1, we establish what we will refer to as the "raw" poll data (given in the second column of Table 1). For years during which there was an election or a referendum, we give preference to these results over poll results. For years during which no survey of opinion poll was conducted, we use an approximate figure in view of the political events of the time.[6]

This table clearly reveals that there were two major periods of political risk (1976-80 and 1990-98) separated by a period of stability. It is worth noting that opinion polls report the voting "intentions" of Quebecers in a referendum on independence. Yet some of these intentions do not actually materialize into actual "Yes" votes in a referendum, and hence overestimate the actual support for sovereignty.[7] Hence, the raw poll data in Table 1 may

also stipulated that if a partnership could not be negotiated, independence would be declared unilaterally.

[5]The federalists gained power in 2003. However, the separatist party is still committed to its platform.

[6]In particular, we use estimates for the years 1983 and 1984 following the defeat of the referendum on sovereignty in 1980, and similar estimates for 1986, 1987, and 1988 based on the election results in which the PQ lost to the federalists in 1985.

[7]It is common knowledge in Quebec that poll results may systematically overstate the Yes vote for several reasons not the least of which is peer pressure. (See Kuran (1990) for arguments indicating that people lie

	Raw Poll Data	Smoothed Poll	Comments
Year	YES† (%)	YES† (%)	
1970	23	–	Provincial election results (1970)
1971	23	–	”
1972	23	23	”
1973	30	25.33	Provincial election results (1973)
1974	31.7	28.23	Opinion poll results (1974)
1975	31.7	31.13	”
1976	31.7	31.7	”
1977	38.17	33.86	Opinion poll results (1977)
1978	51.19	40.36	Opinion poll results (1978)
1979	46.46	45.27	Opinion poll results (1979)
1980	40	45.88	Referendum result (1980)
1981	40	42.15	”
1982	43.75	41.25	Opinion poll results (1982)
1983	30	37.92	Estimate (see text)
1984	30	34.58	”
1985	37.75	32.58	Provincial election results (1985)
1986	30	32.58	Estimate (see text)
1987	30	32.58	”
1988	30	30	”
1989	37	32.33	Opinion poll results (1989)
1990	64.9	43.97	Opinion poll results (1990)
1991	64.76	55.55	Opinion poll results (1991)
1992	63.48	64.37	Opinion poll results (1992)
1993	53.46	60.56	Opinion poll results (1993)
1994	43.08	53.34	Opinion poll results (1994)
1995	49.75	48.77	Referendum result (1995)
1996	45	45.95	Opinion poll results (1996)
1997	45	46.58	Opinion poll results (1997)
1998	45	45	Opinion poll results (1998)

† After apportioning the undecided and discrete vote and after averaging over polls taken in the same year. In accordance with Drouilly's (1996) study, we apportion the undecided and discrete voters by adding three quarters to the NO and one quarter to the YES.

Table 1: Poll/Referendum/Election Results

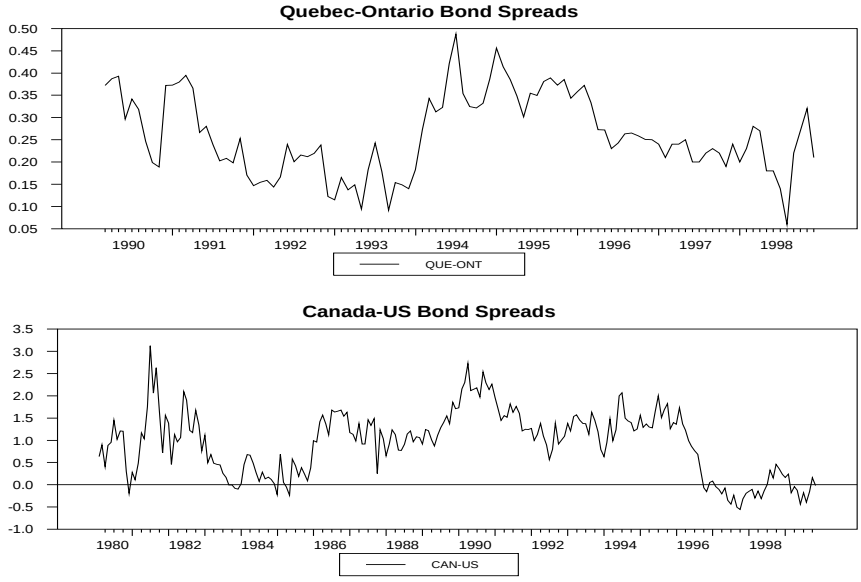

Figure 1: Bond Spreads

overestimate the perceived support of Quebec sovereignty. In Table 1, we also report the predicted values from a 3-year moving average applied to the Yes votes in the raw poll data.[8]

To obtain an alternative indicator of expectations, we also consider data on financial market variables. Johnson and McIlrath (1998) report that opinion poll announcements during the 1995 Quebec referendum that increased the likelihood of Quebec sovereignty

about their voting intentions due to peer pressure.) Election results measure the support garnered by the party in favor of independence. However, since there are only two major political parties (one of which is separatist), public favor may shift from one party to another for reasons (such as public policy issues) other than separation.

[8]The use of a moving average itself will not resolve the problem that the poll data overstate the true sentiment in support of separation. However, if the underlying sentiment in favor of separation follows a more persistent process that is indicated by the fraction of the Yes votes, a moving average applied to the raw poll data may help to eliminate the noise in the raw poll data.

markedly increased spreads of Quebec bond yields over those of both Canada and Ontario yields. Figure 1 displays the difference between the spreads on 10-year bonds for Quebec and Ontario and Canada, respectively.[9] The first panel of Figure 1 shows that spreads between 10-year bonds for Quebec and Ontario increased in 1990 and early 1991 following the failure of the Meech Lake Accord. However, they declined for the remainder of 1991, and for 1992 and 1993 as investors became convinced that fundamental support for separation was lower than 50 percent and that the (federalist) Premier of Quebec would work to diffuse tensions. The difference between the bond spreads rose again in 1994 and 1995 with the provincial election and the referendum but eventually fell after the referendum.

The perception of political risk can also be observed by analyzing the movements in the Canada-US bond spreads. Focusing on the 1990-91 episode, the high long-term bond spreads are partly ascribable to the Bank of Canada's concern about preventing the Canada-US exchange rate from slipping, and partly (from 1991 on) to the radical inflation reduction strategy adopted by the Bank of Canada.[10] However, an additional effect came into play in 1990: the spread was fairly high during the entire Meech Lake episode (June 1990), that is, both before the rejection and after. The high spreads in 1995 can be directly ascribed to the effects of political risk.

[9] In the second panel of Figure 1, the data are monthly from February 1980 to December 1999 while in the first panel of Figure 1, the data are monthly from March 1990 to October 1999.

[10] Inflation was targeted to be reduced to 2 percent in four years 2 (and in fact, the recession helping, the target was achieved even sooner). This strategy, (together with the efforts to maintain the Canada-US exchange rate) required very restrictive monetary policy.

2.3 Investment in Quebec

In this paper, we analyze the impact of political risk on the investment decisions of an *average* (or representative) Quebec firm. First, we examine the relative investment performance in two Canadian provinces, Quebec and Ontario.[11] We consider the behavior of investment in machinery and equipment (M&E) and structures for three broadly defined sectors, namely, manufacturing industries, a broadly defined business sector (which includes manufacturing industries plus construction, transportation, trade, and other services industries) and total industries.[12] Sectoral data on investment and capital stocks include both public and private investment expenditures. To the extent that political risk had an additional effect of reducing public investment in Quebec relative to Ontario, this will be reflected in our data. Figures 2 and 3 display the investment-capital stock ratios for Quebec and Ontario (measured on the right axis) versus the smoothed poll results (shown on the left axis). The smoothed poll results[13], clearly indicate the rise in separatist sentiment and political uncertainty from 1990 to 1998 preceded by political stability from 1981 to 1989.

Table 2 provides a simple test of the impact of political risk on investment in Quebec by testing for the equality of the average investment-capital stock ratio for Quebec ver-

[11] There are two caveats to the above analysis. First, Ontario's economy (as all of Canada) has also been affected by political risk related to the Quebec issue, and second, Ontario's economy has been negatively affected by a social-democratic government in power from 1991 to 1995. However, with respect to the first caveat, the negative impact of political risk on Ontario's economy is substantially less than for Quebec. With respect to the second caveat, the social democratic government in Ontario was defeated by a pro-business conservative government in 1996. As a result, there was a dramatic turnaround in Ontario's economy as early as 1994 as the defeat of the socio-democrats was widely anticipated.

[12] All data are described in Appendix A.

[13] We use the smoothed poll results purely as a descriptive device. In Appendix B, we derive probabilities of separation based on a model of the electoral process.

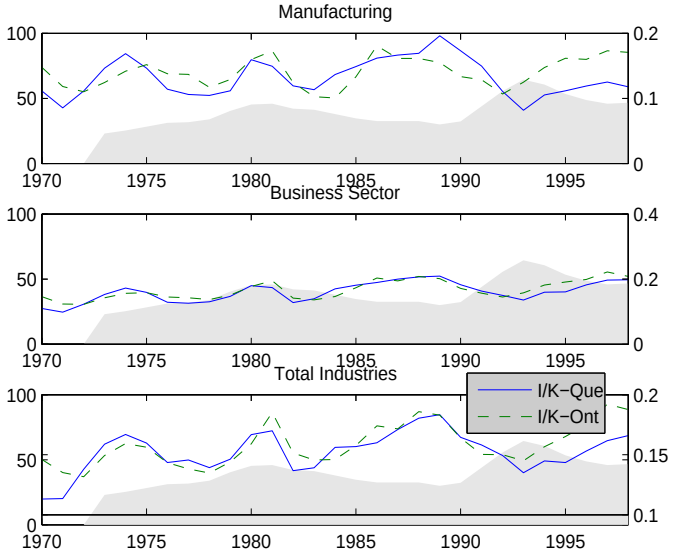

Figure 2: Political Risk versus Investment-Capital Stock Ratios – M&E

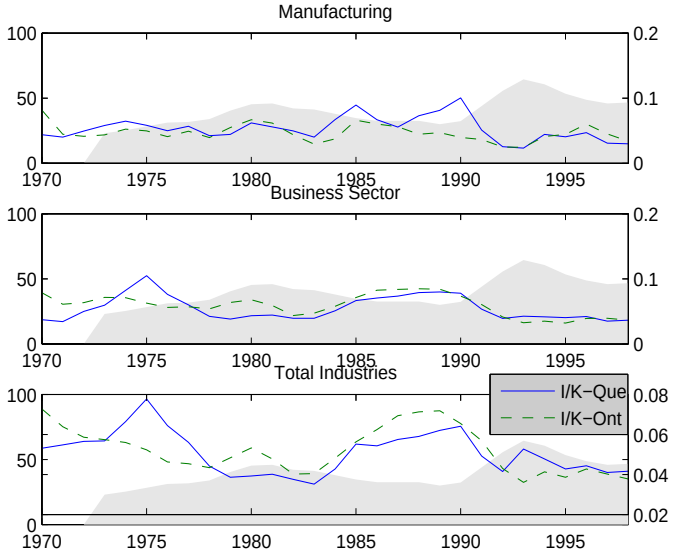

Figure 3: Political Risk versus Investment-Capital Stock Ratios – Structures

	Values of Sample Statistic		
	Manufacturing	Business sector	Total industries
M&E	3.9618	2.6887	2.3661
Structures	1.6208	-6.0114	-6.1052

Periods of political stability and political risk: 1981-1989 and 1990-1998
Sample statistic: $T = \left(\bar{d}_0 - \bar{d}_1\right) / (S\sqrt{1/n_0 + 1/n_1})$, where
$S^2 = [(n_0 - 1)\sigma_0^2 + (n_1 - 1)\sigma_1^2]/(n_0 + n_1 - 2)$

Table 2: Testing for Political Risk, 1981-1998

sus Ontario across periods of political risk and political stability. To net out the effect of Canadian factors such as the recessions of 1980-1982 and 1990-1991, the second episode of political risk (1990-1998) is compared with the second period of political stability (1981-1989). Define the random variable $d_{jt} \equiv [(I/K)_{Que}/(I/K)_{Ont}]_{jt}$,where $j = 0$ refers to the episode of political stability (1981-1989) and $j = 1$ refers to the episode of political risk (1990-1998), respectively. Let μ_0 and μ_1 denote the respective population means. Under the null hypothesis, the expected value of d_{jt} should be equal across the periods of political stability and political risk. From Table 2, the null hypothesis that $\mu_0 = \mu_1$ versus the alternative that $\mu_0 > \mu_1$ can be rejected at the 5% for M&E investment across all three sectors. (The t-value for a one-sided test of the hypothesis that $\mu_0 = \mu_1$ is 1.76 at the 5% level of significance.) The test statistic for structures investment in manufacturing investment is positive and significant at the 10% level but not 5%. However, when we consider the broadly defined business sector and total industries, we find that we can reject the null hypothesis of $\mu_0 = \mu_1$ in favor of $\mu_1 > \mu_0$. Indeed Figure 3 shows that structures investment for broader industry groupings remained high in Quebec owing to the large investment boom in manufacturing structures between 1988 and 1990, due to a strong anticipatory reaction to the 1988 Canada-US Free-Trade Agreement (FTA). Following Alesina, Spolaore, and Wacziarg (2000,2004), this suggests that as economic integration increases, the cost of

political separation for Quebec may decrease, contrary to our original assertions. However, overall we find that the episode of political risk in the 1990's is associated with a significant decline in the investment-capital stock ratio for investment in M&E in Quebec relative to Ontario and similarly for investment in structures for manufacturing industries.

3 A Theoretical Framework

The capital stock may be highly firm-specific or industry-specific such as in aeronautics or aluminum processing, and industry level uncertainty may affect all firms similarly. Hence, if firms wish to sell their excess capital in response to an adverse shock, they may not be able to find buyers. Even for less firm- or industry-specific capital goods, there may exist a "lemons" problem of adverse selection in the market for used capital that may similarly prevent firms from disinvesting. In what follows we abstract from resale markets altogether (i.e., we assume complete irreversibility) which allows for a simpler framework within which to analyze the impact of political risk. In this setting uncertainty has a particularly important impact on investment.

3.1 The basic model

We consider a monopolistically competitive risk neutral firm which makes variable input and investment decisions each period. At time t it produces output, Y_t, using its beginning-of-period capital stock, K_t, and a variable labor input, L_t. The firm's production function is given by $Y_t = F(K_t, L_t, A_t)$, where A_t is a stochastic technology shock and F is twice continuously differentiable, increasing, concave, and satisfies the Inada conditions. Let p_t denote the stochastic output price. We assume a constant elasticity demand function: $p_t = (\alpha_t)^{-\frac{1}{\varepsilon}}(Q_t)^{\frac{1}{\varepsilon}}$ where $\varepsilon < -1$ is the price elasticity of demand and α_t is a stochastic parameter representing the state of demand. Denoting the wage by w_t define the short-

run profit function at t as: $\Pi(K_t, \alpha_t, A_t, w_t) \equiv \max_{L_t>0}\{p_t F(K_t, L_t, A_t) - w_t \cdot L_t\}$. Π is continuous; increasing in K_t, A_t and α_t, decreasing in w_t; strictly concave in K_t, α_t and A_t and bounded for finite K_t, α_t, A_t and w_t. Let r denote the real rate of interest. Define the tax-adjusted price of investment as $p_t^I = (1 - \gamma_t - z_t)\, p_t^k$, where p_t^k denotes the purchase price of investment goods, z_t is the present value of tax deductions on new investment at date t, and γ_t is the investment tax credit at time t as a percentage of the price of the investment good.[14] The firm's after-tax cash flow at time t, R_t, is given by $R_t = (1 - \tau_t)\,\Pi(K_t, \alpha_t, w_t, A_t) - p_t^I I_t$ where τ_t is the corporate tax rate, and I_t is the firm's rate of gross investment measured in physical units at time t. Let $h_t \equiv (A_t, \alpha_t)$. Assume that h_t takes on values in the finite set H and define $f(h_{t+1}|h_t)$ as the conditional density of h_{t+1}. Let primed variables denote next period's values. The firm's problem can be expressed recursively as

$$V(K,h) = \max_I\{(1-\tau)\,\Pi(K,\alpha,w,A) - p^I I + \beta \int_H V(K',h') f(h'|h) dh'\} \tag{3.1}$$

subject to the law of motion for the capital stock $K' = (1-\delta)K + I$, the irreversibility constraint $I \geq 0$ and K given, where V denotes the value function, $0 < \delta < 1$ is the depreciation rate, and $\beta = (1+r)^{-1}$ is the discount factor. Reverting to time subscripts, the first-order necessary and sufficient conditions for the optimization problem at t are

$$\begin{aligned} -p_t^I + \beta E_t V_K(K_{t+1}, h_{t+1}) \leq 0 \quad &\text{if } I_t^* = 0 \\ = 0 \quad &\text{if } I^* > 0. \end{aligned} \tag{3.2}$$

where E_t indicates that expectations are taken conditional on information available at time t and $V_K(K_{t+1}, h_{t+1})$ denotes the partial derivative of V with respect to K or the shadow value of capital. Let $\widehat{h}_t$ be such that: $p_t^I = \beta \int_H V((1-\delta)K_t, h_t) f_h(h_{t+1}|\widehat{h}_t) dh_{t+1}$. When

[14] In this expression, z_t is defined as $z_t = \sum_{n=1}^{T} \tau_{t+n} D_{n,t}\,(1+r)^{-n}$. where $D_{x,t-x}$ is the depreciation allowance per dollar invested for tax purposes for capital equipment of age x on the basis of the tax law effective at time $t-x$, and T is the life of the equipment.

investment is irreversible the firm can be viewed as holding a call option to invest. Define $C_t(K_{t+1}, p^I_{t+1})$ as the call option of investing an additional unit at $t+1$.[15] Also,

$$C_{Kt}(K_{t+1}, p^I_{t+1}) = (1-\delta)E_t \max\{0, \beta E_{t+1} V_K((1-\delta)K_{t+1}, h_{t+2}) - p^I_{t+1}\} \geq 0 \qquad (3.3)$$

is the loss of option value incurred by investing an additional unit at t. By investing an additional unit at t the firm loses flexibility at $t+1$ and beyond since it may wish to disinvest but disinvestment is not allowed. This additional cost of investing must be taken into account when investment is irreversible. Assuming $h_t \geq \widehat{h}_t$, (3.2) becomes:

$$p^I_t + \beta C_{Kt}(K_{t+1}, p^I_{t+1}) \qquad (3.4)$$

$$= \quad \beta E_t\{(1-\tau_{t+1})\Pi_K(K_{t+1}, \cdot) + \beta(1-\delta)E_{t+1}V_K((1-\delta)K_{t+1}, h_{t+2})\} \equiv Q_t + \Upsilon_t$$

where Π_K is the partial derivative of Π with respect to K_{t+1}. On the right-hand side of (3.4) the marginal benefit of investing an additional unit appears as the sum of next period's discounted expected marginal profits and of the expected value of the undepreciated portion of the capital stock assuming the firm does not invest in the next period. The sum of these benefits can alternatively be expressed as $Q_t + \Upsilon_t$ where Q_t represents the expected marginal value of capital if the firm never invests or disinvests from $t+1$ onward and simply allows its capital stock to depreciate and Υ_t captures the increase in value due to only future call options. On the left-hand side is the total cost of investing which is the sum of the purchase price of investment and of the loss of option value of waiting when the firm invests an additional unit. The option to invest will be exercised only when h_t is sufficiently high or when business conditions are sufficiently favorable. If, on the other hand, $h_t \leq \widehat{h}_t$

[15] The call option captures expandability, that is, the firm's option to invest and adjust its capital stock upward in the future should the state of demand and productivity warrant it ($h_{t+1} \geq h^H_{t+1}$). It is the firm's value of waiting to invest. That is, $C_t(K_{t+1}, p^I_{t+1}) = -\int_{h^H_{t+1}}^{\infty} \{\beta E_{t+1}[V((1-\delta)K_{t+1} + I_{t+1}, h_{t+2}) - V((1-\delta)K_{t+1}, h_{t+2})] - p^I_{t+1} I_{t+1}\} f(h_{t+1}|h_t) dh_{t+1}$.

the firm finds itself in the inaction zone so that $K_{t+1} = (1-\delta)K_t$. Hence, irreversibility, uncertainty and expandability lead to a zone of inaction. When business conditions become more unfavorable, the value of waiting increases, the size of the inaction zone rises and the amount invested falls as the marginal loss of option value becomes more important.

3.2 Political risk, the value of waiting and the endogenous risk premium

In this section we modify the model of irreversible investment presented in section 3.1 in order to introduce political risk. Political risk affects investment through its impact on the distributions of the state of demand, productivity and the discount factor. Let $\theta_t = r + \varphi_t$ where φ_t denotes the risk premium for Quebec due to political risk.[16] The firm's stochastic discount factor is $\beta_t = (1+\theta_t)^{-1}$. The state of demand, the state of productivity and the discount factor have different distributions depending on the regime. Suppose that α_t, A_t and θ_t take on values in the sets $\bar{A}$, $\bar{P}$ and $\bar{B}$, respectively, and that they follow first-order Markov processes. That is, letting $h_t \equiv (\alpha_t, A_t, \theta_t)$, $f^{s_t}(h_{t+1}|h_t)$ denotes the conditional density of h_t, given the regime s_t at time t. As we explain below, investors face a less favorable distribution of h in the "bad" regime.

In the model with regime shifts, firms face two regimes, the current regime, regime 0, and a less favorable regime, regime 1, a transition to which may occur with positive probability. We define regime 1 as the separation of Quebec from Canada, a regime which is attainable only if the PQ is in power. We also assume that once separation occurs, it cannot be reversed: Quebec could no longer return to the Canadian federation and regime 0 can no longer be achieved; that is, regime 1 is an absorbing state. Given the PQ in power, the regime shift is governed by a two-state Markov chain with time-varying transition

[16] More generally, we can view the firm as a risky asset with a required rate of return, θ_t where $\theta_t = r + \varphi_t + \pi_t$ where π_t is the equity premium. See, for example, Smith and Wickens (2002), Demers, Demers, and Altug (2003) or Altug and Labadie (2007).

probabilities. Whether a regime shift occurs in this setting depends on the political process, that is, it depends on the realization of two distinct events: which political party is elected and if a separatist party is elected, its chances of winning a referendum. To obtain the total probability of a regime shift, we must take both the electoral process and the regime shifts into account, as follows. Denote by $\chi_{t,00}^{a,l_t^e} = Pr(s_{t+1} = 0 \mid s_t = 0, \boldsymbol{x_t}, a); a = (L, PQ\ )$ the total probability of remaining in the current regime at $t+1$, and $\chi_{t,10}^{a,l_t^e} = Pr(s_{t+1} = 1 \mid s_t = 0, \boldsymbol{x_t}, a); a = L, PQ$ the total probability of a regime shift in period $t+1$ given that Party a is in power and regime 0 is in effect at t, where l_t^e is the *time-to-election* for the government in power. Appendix B describes in detail how the regime shift probabilities are calculated.

The state variables consist of K_t, h_t, a_t, l_t^e and the current regime s_t. The expectation of the future value function depends on which regime is expected to prevail in the future. Furthermore, the probability of elections is incorporated into the transition probabilities using the representation in (B.3) together with the law of motion of the time-to-election l_t^e given in (B.2). Letting primes denote next period's values, the value function for the firm's problem is given by:

$$V(K, h, a, l^e, s = 0) = \max_I \{(1-\tau)\,\Pi\,(K, \alpha, w, A) - p^I I$$

$$+\beta \chi_{10}^{a,\ l^e} \int_H V(K', h', a', l^{e\prime}, s' = 1) f^{s'}(h'|h) dh'$$

$$+\beta (1 - \chi_{10}^{a,l^e}) \int_H V(K', h', a', l^{e\prime}, s' = 0) f^{s'}(h'|h) dh'$$

subject to the irreversibility constraint and (B.2) and (B.3), K given. Suppose we are currently in the "good" regime, i.e., $s = 0$. If $a = L\ or\ PQ$ and $e = 1$ or $a = PQ$ and $e = 0$ (implying that either elections will take place next period, or, the PQ is in power and no elections will take place next period), the probability of a regime change in the next

period is positive, that is, $\chi_{10}^{a,l^e} > 0$ for all values of a. Even if the Liberals have just won the elections today, the probability of a shift to the "bad" regime in the next period is still positive because the total probability of separation takes into account that the PQ may get elected in the future with positive probability. By (B.3), $\chi_{10}^{L,l^e} > 0$. Hence, we find that political risk affects the firm's investment decisions regardless of the party in power.

To give content to our assumption that political risk leads to less favorable distributions for α_t, A_t and θ_t, we will assume that α_t, A_t are stochastically smaller and that θ_t is stochastically larger (in the sense of first-order-stochastic dominance, or FSD) in the "bad" regime.[17] As firms now assign a positive probability of facing lower states of demand and productivity and higher interest rates than in the current political regime downside risk increases. Let $\widehat{h}_t \equiv (\widehat{\alpha}_t, \widehat{A}_t, \widehat{\theta}_t)$ be the value of h_t such that it is optimal not to invest at t.[18] Under irreversibility a shift in the distribution in the range $0 < \alpha_{t+1} \leq \widehat{\alpha}_{t+1}$, $0 < A_{t+1} \leq \widehat{A}_{t+1}$ and $0 < \theta_{t+1} \leq \widehat{\theta}_{t+1}$ induced by political risk will affect the decision as to whether to invest or not as well as the amount invested. This is Bernanke's "bad news principle." As the option value of waiting rises the incidence of a binding irreversibility constraint increases: that is, $\widehat{h}_t$ rises. Furthermore, when it invests, the firm invests a lower amount. Looking at (3.4) we see the impact of political risk through three channels: (1) the loss of option value, C_K, (the impact of constraining the firm in the future by adding an additional unit of capital–by investing the firm reduces its option value of waiting) is enhanced, as making a mistake (i.e. underestimating the probability of separation and the extent to which α_t, A_t and θ_t are less favorable) may be very costly. In the event that separation should take place the firm would be stuck with excess capital which it could

[17] We may also characterize the "bad" regime as involving more volatile, and hence less favorable, distributions for α_t, A_t and θ_t.

[18] $\widehat{h}_t$ is defined by $p_t^I = (1 + \widehat{\theta}_t) \int_H V((1-\delta)K_t, h_t) f_h(h_{t+1}|\widehat{h}_t) dh_{t+1}$ where $I_t = 0$.

not sell (if it is firm or industry specific). Even in the case of less industry specific capital, the possibility of resale even at high discount prices would be very limited, as the economy would be severely depressed. (2) Q_t would fall as the expected marginal value of existing capital would fall; (3) Υ_t, growth options, would also be adversely affected under a scenario of shifting to a "bad" regime.[19] Therefore, the marginal costs of investing rise while the marginal benefits fall so that investment diminishes.

3.2.1 Impact of interest rates

One important impact of political risk even in the "good" regime is through interest rates that rise due to a premium. To evaluate theoretically the impact of the increase in interest rates, assume first that θ_t is *i.i.d.* A shift in the distribution of θ_t in the "good" regime will increase the incidence of a binding irreversibility constraint ($\widehat{h}_t$ rises). Furthermore, if an interior solution exists at t, we obtain from the first-order condition

$$\frac{\partial I_t}{\partial \theta_t} = \frac{p_t^I}{E \int V_{KK}(\cdot) f^{s'}(h'|h) dh'} < 0. \tag{3.5}$$

where E denotes that expectation is taken with respect to the regime-shift probabilities. The risk premium leads to higher interest rates which lower investment. This is the cost increasing effect. When θ_t is serially dependent there is an additional effect of a rise in the current interest rate, namely, the information effect that arises as an increase in θ_t signals a change in future values. Assuming that α, A and θ are mutually independent, so that $f^{s'}(h'|h) = f^{\alpha,\ s'}(\alpha'|\alpha) f^{A,\ s'}(A'|\alpha) f^{\theta,\ s'}(\theta'|\theta)$, the total effect is

$$\frac{\partial I_t}{\partial \theta_t} = \frac{p_t^I}{E \int V_{KK}(\cdot) f^{s'}(h'|h) dh'} - \frac{E \int V_{K\theta} f^{\alpha,s'}(\alpha'|\alpha) f^{A,s'}(A'|A) \left(\partial F^{\theta,s'}/\partial \theta\right) d\alpha' dA' d\theta'}{E \int V_{KK}(\cdot) f^{s'}(h'|h) dh'} \tag{3.6}$$

[19] Admittedly, some firms with more mobile capital would be less stuck. They could move their operations outside of Quebec or even Canada. However, they would suffer from substantial dismantling costs. From the point of view of the Quebec economy, investment in Quebec would fall.

where $\partial F^{\theta,\ s'}/\partial\theta \equiv \partial F^{\theta,\ s'}(\theta_{t+1}|\theta_t)/\partial\theta_t$ is the derivative of the cumulative distribution function of θ_{t+1} with respect to the conditioning variable θ_t. The first term in (3.6) is the negative the cost effect as in (3.5). The second term captures the information effect and will be positive when θ is positively serially correlated, since $\partial F^{\theta}/\partial\theta_t \leq 0$ by FSD, and $V_{K\theta} < 0$. While the total effect is ambiguous, the information effect tends to be quantitatively small so that the cost effect dominates and investment is negatively affected. When θ is negatively serially correlated, the sign of $V_{K\theta}$ is theoretically indeterminate, but $\partial F^{\theta}/\partial\theta_t \geq 0$. In this case, if $V_{K\theta} < 0$ then the information effect is negative, so that both the cost and the information effect of an increase in the interest rate depress current investment.[20]

To gain some additional insight, we rewrite (3.2) as follows. Using the envelope theorem,

$$V_K(K_t, h_t, a_t, l_t^e, s_t) = (1-\tau_t)\,\Pi_K(K_t, \alpha_t, w_t, A_t, s_t)$$

$$+(1-\delta)\min\left[p_t^I, \beta E_t V_K((1-\delta)K_t, h_{t+1}, a_{t+1}, l_{t+1}^e, s_{t+1})\right].$$

where E_t is over the distribution of h as well as over the regime-shift distribution. After substituting for V_K and β_t, equation (3.2) for $h_t \geq \widehat{h}_t$ at t can be re-arranged as

$$c_t + \Phi_t = (1-\tau_{t+1})E_t\Pi_K\left(K_{t+1}, \alpha_{t+1}, A_{t+1}, w_{t+1}\right) \tag{3.7}$$

The right-hand side of (3.7) is the marginal benefit of investing an additional unit. The left-hand side is the total marginal cost which is the sum of the Jorgensonian *cost of capital*, $c_t = p_t^I(\theta_t + \delta) - (1-\delta)(E_t p_{t+1}^I - p_t^I)$ and of a time-varying marginal irreversibility *risk premium* when the firm invests an additional unit, namely,

$$\Phi_t \equiv (1-\delta)\,E_t\{p_{t+1}^I - \min\left[p_{t+1}^I, \beta_{t+1}E_{t+1}V_K\left((1-\delta)\,K_{t+1}, h_{t+2}, a_{t+2}, l_{t+2}^e, s_{t+2}\right)\right]\} \tag{3.8}$$

[20] In Altug, Demers and Demers (2003) we show that the information effect of a change in the investment tax credit (γ) is small so that with positive serial dependence, the cost effect dominates the information effect. We also show numerically that $V_{K\gamma}$ has the same sign for negative as well as positive serial dependence.

As can be seen, the risk premium in interest rates raises the current cost of capital thus lowering investment. In addition, in the *i.i.d.* case, a shift in the distribution of θ_t in the "good" regime makes it more likely that investment will be constrained in the future so that Φ_t rises. In turn, a higher irreversibility risk premium lowers investment at time t. Under reasonable assumptions, a similar conclusion will hold when θ is serially correlated. Thus, the irreversibility risk premium rises with stochastically higher interest rates. In other words, the cost of capital effect and the irreversibility premium effect of higher interest rates both contribute to reducing current investment even in the "good" regime.

4 Numerical Results

Table 3 shows the parameter values used in the simulations. As in the Real Business Cycle literature, we use the steady-state properties of the model or the results of existing studies to determine the values of the parameters.[21] We use data on the determinants of investment such as tax policy, labor costs, and demand and productivity for Quebec to calibrate the model and consider alternative specifications for the regime shift probabilities.

ε	η	τ	δ	β	ρ_A
-4.5	0.3	0.39075	0.075	0.95	0.75
ρ_α	σ_A	σ_α	n_α	n_w	n_p
0.5	0.022	0.065	-0.02	0.005	-0.005

Table 3: Parameter Values

We consider the behavior of a benchmark investment model with one which incorporates some aspect of the experience of political risk in Quebec. Table 4 shows the average investment response denoted $E(I)$, the average investment-capital stock ratio, I/K, and the coefficient of variation of investment, $CV = STD(I)/E(I)$ based on 1000 simulated his-

[21] See Appendix C.

	Summary Statistics		
	$E(I)^{\dagger}$	I/K	CV
I. No regime shifts: $\psi^{a}_{10,t} = 0, a = PQ, L$			
	39,013	0.077	0.801
	(616)	(0.001)	(0.05)
II. Regime shifts: $\psi^{PQ}_{10,t} = 0.50, \psi^{L}_{10,t} = 0$			
(i) Good regime only			
	33,335	0.077	0.884
	(530)	(0.001)	(0.05)
(ii) Bad regime realized in the sample			
	24,277	0.077	0.760
	(404)	(0.001)	(0.04)
(iii) PQ in power			
	31,162	0.076	0.639
	(402)	(0.001)	(0.04)
(iv) L in power			
	35,685	0.076	0.646
	(460)	(0.001)	(0.04)
(v) Political stability to political risk			
	34,898	0.076	0.847
	(698)	(0.001)	(0.05)

† 1997 Canadian dollars per worker

Table 4: Regime Shifts

tories for the demand and productivity shocks that are of 150 periods length. We assume that the α_t and A_t are lognormally distributed and approximate the continuous distributions with discrete Markov processes in each regime using the procedure in Tauchen (1986). We consider 11 points in the discrete grid for the exogenous shocks. The first part of Table 4 presents the investment response for our baseline specification, the case without regime shifts.[22] The second part of Table 4 presents the average investment response when there exists a positive perceived probability of transiting to a less favorable regime by firms. In the simulations reported in Part II, the "bad" regime is assumed to be characterized by

[22] We note that the model cannot match the *level* of the actual investment response very accurately. As a point of comparison, the average de-trended investment per worker (including residential investment) during the period 1990-1998 was around $11,000 per worker (in 1997 Canadian dollars). This is a broader measure of investment than we considered in Section 2.

distributions for demand and productivity that have level means that are 10% lower than in the "good" regime, holding the level variances constant.We draw realizations of the random variable s_t denoting the current regime by making use of the properties of the electoral process as described in Section 3.2. For the period 1990-1998, we take $\psi_{10,t}^{PQ}$ equal to 50%. The probability of a regime shift, conditional on $a = PQ, L$ being in power, is given by the relation in (B.3).

For the parameterization in part II of Table 4, $\chi_{t,10}^{PQ,l^e}$ varies as 0.5, 0.4090, 0.3768, 0.3306, and 0.3013 as the number of periods until elections falls from 5 to 1. By contrast, $\chi_{t,10}^{L,l^e}$ increases as 0.0, 0.0910, 0.1232, 0.1694, and 0.1987 as l_t falls. When the PQ is in power at t, the probability of achieving separation falls as the election date approaches and a change in governing party becomes more probable. The opposite is true when the federalist party is initially in power at t since in this case the probability of achieving separation increases as the election date approaches and a change in governing party becomes more probable.

4.1 The long-run impact

Table 4 illustrates the long-run behavior in an economy subject to stationary shocks to demand and productivity and to regime shifts arising from the nature of the party in power. In the steady-state I/K is stochastic in view of serially correlated shocks to demand and productivity.[23] Table 4 shows that averaging over all values of the shocks, the average investment-capital stock ratio is approximately equal to the exogenous rate of depreciation for all specifications of the model. Our interest lies in examining the average investment response.

Consider the investment response of firms with regime shifts, which can be computed

[23]It is also stochastic when the discount factor is stochastic even it is *i.i.d.*

conditional on remaining in the "good" regime, so that the separation state is not realized in the sample, or by allowing for the separation state to occur in a probabilistic manner during the sample period. We observe that the probability of a regime shift at some future date induces firms to lower their investment today. Table 4 shows even if separation has never been realized in the sample, investment falls by 14.6% compared to the case without regime shifts. As in Danthine and Donaldson (1999), our results indicate that the presence of an absorbing state, namely, a state from which the economy cannot transit once it has entered into it, has a significant negative effect on investment even if such a disaster state has never been observed in the sample. Comparing these results with the actual investment response in Quebec, we note that the de-trended levels of investment per worker, fell by 22%, 18% and 16% for M&E investment in manufacturing, the business sector and total industries during the period of political risk in Quebec relative to the period of political stability in the 1980's. Part (II.ii) of Table 4 also shows that if the separation state were realized during the sample period (in a probabilistic sense), then investment declines by nearly 37.8% in the long-run.[24] It is in this context that the various subjective indicators of sentiment in favor of separation gain importance: to the extent that investors incorporated such beliefs into their real investment decisions, even a relatively low likelihood of transiting to a less favorable regime implies a significant decline in investment. Our exercise may also be interpreted in the following manner: Given the subjective indicators in favor of separation, by how much do demand or productivity need to fall in the "bad" regime to generate the observed decline

[24] Whether such a significant drop in investment would occur depends on whether separation is permanent and the circumstances under which it occurs. Consider the situation in Cyprus where separation has led to a permanent reduction in market access and economic integration. A long period of investment stagnation has followed.

in investment in Quebec? Our analysis predicts that when the regime shift probabilities are specified by making use of the nature of the actual electoral process and the opinion poll results, a 10% decline in demand and productivity in the "bad" regime is sufficient to lead to a decline in investment that is in line with observed investment shortfall in Quebec.

Our results also show that when the firm can adjust its capital stock optimally over the long-run, a non-zero probability of transiting to the "bad" regime implies that the long run steady state capital stock is lower. This occurs because the investment-capital stock ratio is unchanged but the long-run level of investment has fallen. Abel and Eberly (1999) argue that there are two effects of an increase in risk with irreversibility: the first refers to the short-run or trigger effect while the second refers to the long-run or hangover effect. In the latter case, the inability to disinvest implies that firms may find themselves with too much capital. Our results imply that the trigger effect dominates so that the long-run capital stock with regime shifts is lower relative to the situation in which the current regime, namely, regime 0, is expected to prevail permanently. This occurs even if the "bad" regime has never been observed in the sample.

4.2 The short-run impact

In our previous analysis, we did not distinguish between the party in power at the initial date, namely date 1, because this does not affect the long-run investment response. Furthermore, in our simulations, the party in power switches in a probabilistic sense. However, it may be of interest to examine the investment response conditional on one of the parties remaining in power for a certain period of time. That is, we allow elections but we assume that the same party is reelected for several consecutive elections. In Part II (iii) and (iv) of Table 4, we simulate the response of investment conditional on the PQ or L remaining

in power. For simplicity, we use the decisions rules contingent on having 5 periods left in office and consider shocks from the distributions for demand and productivity in the "good" regime. We observe that allowing the PQ to remain in power for the foreseeable future leads to a significant decline in investment as the likelihood of achieving separation increases. Investment is lower by nearly 6.5% compared to the situation where the party in power is likely to change, and by 20.12% relative to the situation without regime shifts (due to the risk of separation). By contrast, if the federalists were to remain in power for the foreseeable future, the probability of separation diminishes and investment would be nearly 6.6% higher compared to the situation with the normal switching of parties during elections and only 8.5% lower relative to the situation without regime shifts. Such was the case during 1985-1989, which is a period of political quiescence as far as the separation issue is concerned, when investment rates are found to be significantly higher than in the 1990s. Thus, it is of interest to note that our model delivers predictions that can match these observations.

In a final experiment, we model the transition from the period of political stability in the 1980's to the period of political risk in the 1990's. Specifically, taking into account poll data, we simulate the investment response implied by the model by letting $\psi_{10,t}^{PQ} = 0.40$ for the first 60 periods, and letting $\psi_{10,t}^{PQ} = 0.50$ for the remaining periods. In other words, as the poll data indicate, had the PQ succeeded in gaining power during the period of political stability, the probability of their effecting separation would have been significantly less that 50%. Thus, we take $\psi_{10,t}^{PQ} = 0.40$. By contrast, during the 1990's, an exogenous political event, namely the breakdown of the Meech Lake Accord in 1990, aroused separatist sentiment as reflected in poll data so that in the event of the PQ winning elections (which

it did in 1994) the probability of a regime shift would be 50%. Thus, we take $\psi_{10,t}^{PQ} = 0.50$. The last row of Table 4 shows that the overall decline in investment relative to the situation without regime shifts is 10.5%. Since this scenario captures most accurately the situation in Quebec during the period of political risk, we find that what we termed the political risk channel of the risk of separation can lead to a decline in investment that is in line with observed values.

4.3 The risk premium in interest rates

In our framework, political risk affects investment through a perceived probability of a change in regime and also through a higher discount rate for firms' present value maximization problems. Evidence from a number of studies suggests that political risk had a significant effect on asset returns in Quebec.[25] While our results from the previous section imply that the perceived threat of transiting to the separation state could be responsible for the observed decline in investment in Quebec, another possibility is that investment fell due to the increase in the firms's cost-of-capital and irreversibility premium in the "good" regime. To examine this claim, we proxy the firm's required rate of return by a baseline interest rate plus the bond spreads. The mean and standard deviation for the Quebec-Ontario bond spreads are given by 0.2589 and 0.0890 for the period 1990:03-1998:12. However, these bond spreads increased up to 0.3419 in July 1990 after the collapse of the Meech Lake Ac-

[25] Beaulieu, Cosset, and Essaddam (2005) show that political news associated with the possible separation of Quebec from Canada plays an important role in the volatility of stock returns in Quebec. Tirtiroğlu, Bhabra, and Lel (2004) examine the impact of announcements of business relocations from Quebec. As in this paper, they use Toronto (Ontario) as a control. Both papers quote extensively from material in an earlier version of this paper, and use various arguments put forward by us to justify their analysis regarding the role of political risk.

	Summary Statistics		
	$E(I)^{\dagger}$	I/K	CV
I. No regime shifts: $r_t \in \{5.26, 5.78\}$			
	37,487	0.077	0.815
	(604)	(0.001)	(0.05)
II. Regime shifts: $r_t \in \{5.26, 15\}$			
(ii) Good regime only			
	23,368	0.084	1.541
	(588)	(0.002)	(0.05)
iii) Bad regime realized in the sample			
	14,360	0.077	1.403
	(349)	(0.001)	(0.06)
iv) Political risk to political stability			
	25,252	0.082	1.363
	(614)	(0.001)	(0.06)
III. A "Sudden Stop"			
	12,075	0.060	2.077
	(613)	(0.0004)	(0.09)

† 1997 Canadian dollars per worker

Table 5: Stochastic Interest Rates

cord, to 0.4873 in July 1994 preceding the provincial election, and to 0.4562 in February 1995 in the run-up to the 1995 referendum. Hence, we define a 2-state process for the real interest rate which takes on the values $r_{1t} = 5.26\%$ and $r_{2t} = 5.78\%$. We consider only *i.i.d.* interest rates, and assume that the probabilities for the high and low rates are given by $p = 0.5$. Under this assumption, the mean of the implied interest rate process is 5.52%, which equals the sum of the baseline interest rate plus the mean of the Quebec-Ontario spread, and the population standard deviation is 0.26.[26] The first part of Table 5 shows that changes in the discount factor of the magnitude observed in the sample cannot account for the decline in investment. Compared to the baseline model, we note that fluctuations in interest rates of a magnitude observed in the data yield an investment decline of only 4.47%. Clearly this is too low to match any of the features of the actual data.

[26] While the implied standard deviation is considerably higher than the standard deviation for the observed bond spreads, the volatility of the bond spreads are likely to underestimate the volatility of the discount factor for individual firms in Quebec.

4.4 A "Sudden Stop"

The results of the previous section suggest that the financial market channel alone seems incapable of rationalizing the observed investment response in Quebec. Another possibility is that investors may have expected large increases in market risk premia in the event that separation had occurred, provoked, for example, by the problem of the apportionment of the Canadian federal debt between Canada and Quebec, uncertainty about the future of the Canadian dollar, a potential banking crisis, capital flight and the institution of capital controls by a separate Quebec, and so on.

Here, we consider an alternative version of the political risk channel that operates through large expected increases in the (exogenous) risk premium facing firms in the "bad" regime. Specifically, we assume that $r_t = 5.26\%$ in the "good" regime, but that it fluctuates with equal probabilities between $r_{1t} = 5.26\%$ $r_{2t} = 15\%$ in the "bad" regime. As before, we assume that the distributions for demand and productivity have 10% lower means in the "bad" regime. Table 5 shows that if investors expect higher interest rates or higher risk premia in the "bad" regime, investment declines by close to 40% relative to the situation without regime shifts and by 30% relative to the situation without increases in risk premia. Thus, investment falls both because expected future cash flows are lower, and also because investors expect to discount the cash flows at a higher rate. This occurs even if separation has not been observed in the sample.[27] If separation does occur in a probabilistic sense, then the decline in investment is 57% if no regime shifts are expected. As in Table 4, we can also consider a transition from the period of relative political stability in the 1980's to a situation with political risk in the 1990's. Assuming that the transition is known ex

[27] While these declines may seem large, for firms that expected a 10 percentage point in their real interest rate or cost-of-capital, a decline of a further one-third in their investment is not inconceivable.

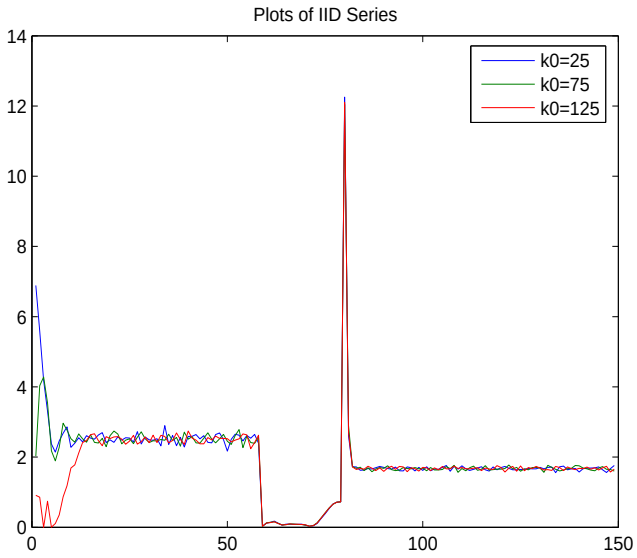

Figure 4: A "Sudden Stop"

ante, then investment declines around 35% if investors expect worse fundamentals for demand, productivity, and real interest rates in the "bad" regime. Combining these results with those reported in Table 4, we conclude that the expectation of higher interest rates or higher risk premia in the "bad" regime is an important channel through which political risk must have made its effects felt.

The sequence of events following the separation decision might appear similar to those in a "sudden stop."[28] Evidence from a number of "sudden stop" situations suggests that real interest rates can register dramatic increases over brief periods. As a final exercise, we consider a known transition to the "bad" regime with higher interest rates. Specifically, we assume that the real interest rate is $r_t = 5.26\%$ in the "good" regime, but in the "bad" regime, it rises to $r_{2t} = 50\%$ during a brief transition of 20 periods, and then randomly

[28] For a discussion of "sudden stops" see, for example, Arellano and Mendoza (2003).

fluctuates between the values of $r_t = 5.26\%$ and $r_t = 15\%$ afterwards.[29] Figure 4 shows that investment essentially collapses during the transition beginning with period 60 and the long run value of the coefficient of variation (CV) increases by 30% even compared to a situation in which the "bad" regime is realized in a probabilistic sense. More interestingly, we observe that a transition of this sort also reduces the investment-capital ratio.[30] These results appear to be line with our view of events that would accompany such a transition. Our model predicts that once a financial crisis is precipitated, perhaps as a function of political events, we would tend to observe large declines and high volatility in real investment and real output. Note that the simulations indicate that there is an increase in investment as the economy exits from the acute crisis stage. Many economies do display some increase in investment following a crisis as the economy works back to so-called "normal" capacity.[31]

5 Conclusions

In this paper, we have studied the impact of political risk on real investment decisions. There is a large literature that studies the negative effect of political risk on investment behavior. Much of this literature lacks an explicit theoretical focus, and uses regression-

[29] For example, during the 2001 Argentinian crisis, the lending rate in US dollars rose to 23% and the country risk premium rose to 53%. Likewise, overnight lending rates in Argentina rose to 689% on November 30, 2001 while those in Turkey during the most acute period of the 2000-2001 financial crisis reached astounding levels such as 4,018.6% on February 21, 2001. (See Özatay and Sak, 2003.).

[30] Interest rate premia would have an even stronger impact on investment in a context where firms face financial market imperfections. See, for example, Demers, Demers, and Altug (2003), Section 4.8. Thus, allowing for financial market imperfections would mean that lower values of the interest rate than the ones we assumed would elicit the same investment response that we have obtained in our simulations.

[31] In the above example, we have assumed that the economy transits to the "bad" regime so that investment converges to a lower and less variable level.

based or reduced-form techniques to uncover the importance of political risk on investment behavior.[32] Unlike much of this literature, we have used a fully articulated model of firms' investment decisions that incorporates a perceived probability of transiting to a regime with worse fundamentals. Allowing for actual features of the electoral process that govern the regime switch, we have examined the role of expectations regarding demand, productivity, or interest rates in a future unobserved regime in determining current investment outcomes. Our analysis is in the spirit of a "reverse calibration" exercise. We find that when the regime shift probabilities are specified by making use of the nature of the actual electoral process and the results of opinion poll data, a 10% decline in demand and productivity in the "bad" regime is sufficient to lead to a decline in investment that is in line with observed investment shortfall in Quebec.[33] Allowing for increases in risk premia in the "bad" regime causes larger potential declines in investment today. In the absence of expectational effects, we find that the investment shortfall due to increases in interest rates in the current regime, for example, are too small to rationalize the observed declines in investment in Quebec.

Much of the literature on the determinants of foreign direct investment or capital flight has been concerned with identifying the nature of the risk premia due to political risk. In our model of irreversible investment, we have shown that political risk increases downside risk and raises the option value of waiting. Political risk increases the endogenous irreversibility premium and, hence, the marginal cost of investing, while at the same time it leads to a decline in marginal benefits as it reduces the marginal value of capital and growth options. As marginal costs increase and marginal benefits fall, the incidence of the binding

[32] See Harms (2000) for a recent review.

[33] It is interesting to note this is of a lower magnitude than observed in Great Depressions (see Kehoe and Prescott, 2002, whose working definition is 20% below trend) or other crises.

irreversibility constraint rises and total investment falls. Using numerical simulations that capture key features of the Quebec economy, we have shown how the irreversibility premium interacts with a perceived probability of transiting to a regime with lower demand or productivity or higher interest rates to yield significant declines in investment that could not be explained by changes in current fundamentals alone. We have also shown how the same mechanisms can lead to "sudden stop"-type phenomena – with sharp and prolonged contractions in investment and output – as an economy experiences a temporary period of high and volatile interest rates in the transition to a regime with permanently worse fundamentals.

While, for simplicity of exposition, we have abstracted from financial market imperfections, in the presence of such imperfections, the impact of a financial crisis on investment will be magnified. Hence our results may be viewed as providing a more conservative estimate of the impact of political risk on investment. To simplify the exposition, we have also assumed that total factor productivity is exogenous. In an earlier version we have explored the implications for TFP or TFP growth to depend on investment. This framework provides an additional channel for political risk to affect growth through lower current productivity or productivity growth.

In this paper, we have studied a specific case of political risk. However, our framework could also be used to study the impact of uncertainty about the sustainability of monetary, fiscal and exchange rate policy – all of which are important risk factors facing individual firms. It could also be used to examine the investment response following the adoption of structural adjustment programs when there is uncertainty about the policy-maker's resolve or its ability to implement the reforms.

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A Data Appendix

The data are derived from Statistics Canada, various divisions. The end-of-period net capital stock K_t is defined as the cumulated value of gross capital formation minus capital consumption allowances from some initial date up to period t based on delayed depreciation. Investment I_t is measured as gross capital stock formation at annual rates. Real capital stocks and investment are measured in 1997 Canadian dollars. These data contain information on both private and public capital stocks for machinery and equipment, road repairs, and non-residential structures for 2-digit SIC code industries.[34] Q_t is measured as Gross Domestic Product (GDP) for Quebec, in chained 1997 Canadian dollars. The labor market data are annual averages of monthly data for the period 1983:1-2002:1. L_t denotes the number of employees in firms of all sizes in Quebec times the average weekly hours (including overtime) of hourly employees times 50. Nominal wages are measured as the ratio of average weekly earnings (including overtime) to average weekly hours, all employees in firms of all sizes by sector. Finally, S_t denotes manufacturing shipments for Quebec, measured at annual rates for 1981:1-2002:1. The price of output p_t is measured as the implicit price deflator for final domestic demand for Quebec, with base year 1997. The price of capital p_{Kt} is measured by the implicit price deflator for investment by sector and by type of investment for Quebec. All prices are measured relative to the price of final domestic demand for Canada.

[34] See the Statistics Canada publication *Fixed Capital Flows and Stocks: Methodology*, Cat. No. 13-568 for a further description.

B The Regime Shift Probabilities

In this appendix, we describe how the regime shift probabilities used in Section 3.2 are calculated.

We begin by describing the electoral process in Quebec. There have been two major political parties in Quebec: the federalist Liberal Party of Quebec (L) and the separatist Parti Quebecois (PQ). The term in office is a maximum of 5 years according to the Constitution. [35] To model the electoral process we consider a Poisson process where the electoral outcome, a, may take on two possible values, L and PQ. In the first year after elections, the probability that the winner will still be in power in year two is given by $e^{-\lambda}$ with $\lambda = 0.2$ so that $1/\lambda = 5$ years is the expected duration of the term in office. We assume a symmetric matrix:

$$\Gamma = \begin{bmatrix} \text{Prob}(L|L) & \text{Prob}(L|PQ) \\ \text{Prob}(PQ|L) & \text{Prob}(PQ|PQ) \end{bmatrix} = \begin{bmatrix} e^{-\lambda} & 1-e^{-\lambda} \\ 1-e^{-\lambda} & e^{-\lambda} \end{bmatrix} = \begin{bmatrix} .818 & .182 \\ .182 & .818 \end{bmatrix} \quad \text{(B.1)}$$

According to Γ, the probability that a government newly elected at t will remain in power at $t+1$ is given by 0.818. This probability captures the fact that elections may take place at both t and $t+1$. However, we make two observations: first, such an event is not observed in the data, and more generally, the probability of an election one year after the current party takes office is close to zero. Furthermore, the probability of remaining in power is not constant (at 0.818) but declines over the electoral cycle. To capture these facts, let us define l_t^e as the *time-to-election* for the government in power, where l_t^e evolves as

$$l_t^e = (1 - e_t)(l_{t-1} - 1) + e_t \cdot 5 \quad \text{(B.2)}$$

[35] In practice, elections have sometimes been called as early as after 2 years in office and sometimes as late as 5 years, as parties try to time elections to maximize their chances of being elected.

where $e_t = 1$ if there are elections at t and $e_t = 0$ if there are no elections. For a newly elected government at time t, $l_t^e = 5$. We define the probability of a shift in the party in power at $t+1$ as $\Gamma^{5-l_t^e} = \Gamma^0$ which indicates that the party that just won the elections is expected to continue in the next year with probability one. With no elections taking place at $t+1$, then $l_{t+1}^{e=0} = 4$ and, as of $t+1$, economic agents expect the party in power to continue at $t+2$ according to the matrix $\Gamma^{5-l_{t+1}^e} = \Gamma^1$. Similarly, at $t+2$, $t+3$ and $t+4$, $l_{t+2} = 3$, $l_{t+3} = 2$, and $l_{t+4} = 1$ respectively, and the probability of the incumbent remaining in power at $t+3$, $t+4$ and $t+5$ is given by $\Gamma^{5-l_{t+2}} = \Gamma^2, \Gamma^{5-l_{t+3}} = \Gamma^3$ and $\Gamma^{5-l_{t+4}} = \Gamma^4$ respectively. Since elections must take place at $t+5$, note that Γ^4 assigns 0.58 probability that the incumbent will win the elections and 0.42 probability that the opposition party will win instead. There is an incumbent advantage.[36] At $t+6$, elections have just taken place, so $l_{t+6}^{e=1} = 5$ and the cycle starts anew.

Define $s_t = 0$ as the current regime and denote by $\psi_{t,00}^{PQ} = Pr(s_{t+1} = 0 \mid s_t = 0, \boldsymbol{x_t}, PQ)$ as the probability of remaining in the current regime at $t+1$ given that the PQ is in power, and $\psi_{t,10}^{PQ} = Pr(s_{t+1} = 1 \mid s_t = 0, \boldsymbol{x_t}, PQ)$ as the probability of a regime shift in period $t+1$ given that regime 0 is in effect at time t. We note that $\psi_{t,00}^{PQ} = 1 - \psi_{t,10}^{PQ}$ and also that $\psi_{t,\ 01}^{PQ} = 0$ since regime 1 is an absorbing state. In these expressions, $\boldsymbol{x_t}$ is a vector of economic and political variables observed at time t which firms use to assess the probability of transition to next period's regime. When L is in power $\psi_{t,\ 00}^{L} = 1$ and $\psi_{t,\ 10}^{L} = 0$. Hence, we can define the vectors $\psi_{t,10} = \left[0, \psi_{t,10}^{PQ}\right]$ and $\psi_{t,00} = \left[1, \psi_{t,00}^{PQ}\right]$.

To obtain the total probability of a regime shift, we must take both the electoral process

[36] We abstract from exogenous events such as scandals which may alter these probabilities. The incumbent advantage implied by Γ^4 may also be eliminated by using the unconditional probability of 0.5 that either party may win the elections.

and the regime shifts into account, as follows. Denote by $\chi^{a,l_t^e}_{t,\ 00} = Pr(s_{t+1} = 0 \mid s_t = 0, \boldsymbol{x_t}, a); a = (L, PQ\ )$ the total probability of remaining in the current regime at $t+1$, and $\chi^{a,l_t^e}_{t,10} = Pr(s_{t+1} = 1 \mid s_t = 0, \boldsymbol{x_t}, a)\ ; a = L, PQ$ the total probability of a regime shift in period $t+1$ given that Party a is in power and regime 0 is in effect at t. Assume that L has just won the elections. There is a probability $e^{-\lambda}$ of L being in power in the next period in which case the regime shift occurs with probability $\psi^L_{t,10} = 0$. Also given L in power there is a probability $1-e^{-\lambda}$ of the PQ being in power in the next period. In this instance separation would occur with probability $\psi^{PQ}_{t,\ 10}$. Hence, the total time-t probability that a regime shift will occur at time $t+1$ with *time-to-election* $l_t^e = 5$ is $\chi^{L,l_t^e}_{t,10} = (e^{-\lambda})0 + (1-e^{-\lambda})\psi^{PQ}_{t,10}$. If the PQ just won the elections instead of L, then we have $\chi^{PQ,l_t^e}_{t,10} = (1-e^{-\lambda})0 + (e^{-\lambda})\psi^{PQ}_{t,10}$. Define the vector $\chi^{l_t^e}_{t,\ 10} = \left[\chi^{L,l_t^e}_{t,10}, \chi^{PQ,l_t^e}_{t,10}\right]$. Hence, conditional on L or PQ being in power, we can determine the probability of observing a regime shift next year as:

$$\chi^{l_t^e}_{t,10} = \psi_{t,10}\Gamma^{5-l_t^e} \tag{B.3}$$

where *time-to-election* l_t^e evolves according to (B.2).[37] Suppose, for example, that the PQ is in power and there are three periods left until elections, $l_t^e = 3$. Using the definition of the matrix Γ^2 with $\lambda = 0.2$, the total probability of a regime switch is given by $\chi^{PQ,l_t^e}_{t,\ 10} = 2(0.182)(0.818)0 + [(0.182)^2 + (0.818)^2]\psi^{PQ}_{t,\ 10}$. We can similarly obtain the probability of

[37] This specification of the transition probabilities takes into account that in principle, elections could take place every period (except the first period after elections) with a positive probability. It may be more realistic to allow the incumbent party to stay in power with probability one for the first three years of its term, and give positive probability of mid-term elections only in the fourth and fifth years. In this case, we can specify $\chi_{t,10} = \psi^{TR}_{10,\ t}\Gamma^{d(5-l_t)}$ where the indicator function $d = 0$ for $l = 4, 3$, and $d = 1$ for $l = 2, 1$. In our simulations, we conducted the experiments with this alternative scheme, but found little to no impact on the results.

a regime switch conditional on L being in power with $l_t^e = 3$. Hence, we observe that the probability of a regime switch depends on the party in power as well as on the number of years the party in power has held office (that is, l_t^e). Likewise, conditional on the party in power, we can define $\chi^{a,l_t^e}_{t,\ 00} = 1 - \chi^{a,l_t^e}_{t,\ 10}$ as the probability of no regime switch. Since we assume that regime 1 is an absorbing state,[38] $\chi^{l_t^e}_{t,\ 01} = 0$ and $\chi^{l_t^e}_{t,\ 11} = 1 - \chi^{l_t^e}_{t,\ 01} = 1$.

C Parameterizing the Model

Evidence on returns to scale and markups for the Canadian economy are mixed. Paquet and Robidoux (2001) provide evidence that there exists constant returns to scale and perfect competition for the Canadian economy as a whole when variable capacity utilization is taken into account. By contrast, both Morrison (1992,1994) and Robidoux and Lester (1992) find some evidence for increasing returns to scale at the industry level for Canada between 1960 and 1982. However, their evidence is also consistent with constant returns to scale. Morrison (1992,1994) reports markup estimates for Canadian manufacturing firms between 1960 and 1982. The average markup reported in her first study is equal to 1.1358, with a standard deviation of 0.0435 while the average markup reported in her second study is 1.1942, with a standard deviation of 0.07766. The markups in her second study show an increasing trend, being equal to 1.087, 1.157, 1.249, 1.285, and 1.193 for the years 1962, 1967, 1972, 1977, and 1982, respectively.

[38] An alternative would be to assume that $\chi_{t,01} > 0$. In this case, should a policy shift to regime 1 occur at some time $\widehat{t} < t$, there would be a possibility of returning to the status quo ante at some future date. This formulation assumes that should separation occur, investors continue to place a small probability of Quebec remaining in the federation. Even in the absence of an absorbing state, we would still expect the nature of the party in power and the electoral cycle to affect the transition probabilities.

In our empirical application, we allow for constant returns to scale and imperfect competition. The firm's production function is assumed to have the Cobb-Douglas form $Q_t = A_t K_t^{\eta} L_t^{1-\eta}$ where A_t is a stochastic shock to technology, and $0 < \eta < 1$. The inverse demand function is the constant elasticity demand function. The firm's short-run profit function that has been optimized over the variable factors of production has the form

$$\Pi\left(K_t, \alpha_t, A_t, w_t\right) \equiv \nu \alpha_t^{1-\mu_1} K_t^{\mu_1} A_t^{\mu_2} w_t^{\mu_3},$$

where w_t denotes the variable stochastic input price.[39] Under constant returns to scale, the firm's revenue function is homogeneous of degree one in capital and labor. Hence, we evaluate the revenue function in terms of per worker quantities. In the optimized version of the profit function, this implies that demand is also measured as demand per worker. The technology shock is measured as the Solow residual $\ln(A_t) = \ln(Q_t) - \eta \ln(K_t) - (1 - \eta) \ln(L_t)$, where Q_t is measured as Quebec gross domestic product, K_t denotes the end-of-year capital stock in M& E and structures for all industries and L_t is total annual hours worked in Quebec. The Solow residual is based on aggregate as opposed to sectoral output, capital stock, and employment data for Quebec. A measure of demand shocks per worker is obtained as $\ln(\alpha_t) = \ln(SHIP_t) - \varepsilon \ln(p_t)$, where p_t is the implicit price deflator for final domestic demand in Quebec and $SHIP_t$ refers to manufacturing shipments per worker in Quebec. In typical Real Business Cycle models, the capital share is usually assumed to equal $\eta = 0.36$.[40] Corresponding to the narrower definition of capital in our model, we assume $\eta = 0.3$. The elasticity of demand is determined from a static version of the firm's problem, which states that the markup of price over marginal cost can be expressed as

[39] Letting $a = (1 - \eta)(1 + \varepsilon)$ and $b = 1 - \eta(1 + \varepsilon)$, $\nu = [N^{-a/b} - N^{-\varepsilon/b}] > 0$, $N = (1 + \varepsilon)\varepsilon^{-1}(1 - \eta) < 1$, and $0 < \mu_1 = -\eta(1 + \varepsilon)/(1 - \eta(1 + \varepsilon)) < 1$, $\mu_2 = \mu_1/\eta$ and $\mu_3 = a/b$.

[40] See, for example, Danthine, Donaldson, or Mehra (1989).

MRKP $= \varepsilon/(1+\varepsilon)$. Based on Morrision's (1994) study, we set $\varepsilon = -4.5$, which corresponds to a markup of 28%.

The corporate tax rate τ_t is measured as the weighted average of the federal corporate income tax rate τ^F. The combined corporate tax rate τ_t is computed as $\tau^S\tau^F + \tau^P$, where τ^P denotes the provincial corporate tax rate and τ^S denotes the surtax that was used to raise additional tax revenue at the federal level without raising federal corporate taxes. The investment tax credit γ_t is measured as the federal investment tax credit applied to M&E and nonresidential structures, and z_t denotes the present value of \$1 of future capital cost allowances for investment in M&E and for non-residential structures by assuming that the future corporate tax rates are constant. Prior to 1987, the average corporate tax rate is given by $\tau = 0.4351$ whereas after the 1987 Tax Reform Act, it falls to $\tau = 0.3909$. Since the simulations refer more appropriately to the post-1987, we take $\tau = 0.3909$.

In the model presented in Section 3, no account was made of the trends. Using a larger sample from 1963-1998, augmented Dickey-Fuller and Phillips-Perron unit root tests are used to test for the presence of trends in the sectoral investment and capital series measured per worker in Quebec. The Dickey-Fuller tests indicate rejection of the unit root hypothesis for almost all the investment and capital stock series at significance levels close to 5%. For the Phillips-Perron tests, the results are more mixed. We also tested for unit roots in the exogenous series such as the tax-adjusted prices of investment goods, real wages, productivity, demand, and interest rates. For some of these series, we are unable to reject the unit root hypothesis. However, tests that are based on shorter samples are likely to have low power to reject the null.

The model is thus formulated with trend-stationary processes. The processes for demand

per worker, productivity, real wages and the tax-adjusted price of capital are assumed to evolve as $\zeta_t = (1 + n_\zeta)\tilde{\zeta}_t$, where $\tilde{\zeta}_t$ is the stationary component and n_ζ denotes the trend for $\zeta = \alpha, A, w, p^I$. The transformed value function is given by:

$$\tilde{V}_t = \max_{\tilde{K}_{t+1}} \left\{ \nu(\tilde{\alpha}_t)^{1-\mu_1} \tilde{K}_t^{\mu_1} \tilde{A}_t^{\mu_2} \tilde{w}_t^{\mu_3} - \tilde{p}_t^I [\tilde{K}_{t+1} - (1-\delta)\tilde{K}_t] + \bar{\beta} E_t \tilde{V}_{t+1} \right\}, \tag{C.1}$$

subject to the irreversibility constraint $\tilde{K}_{t+1} \geq (1-\delta)\tilde{K}_t$, given $\tilde{K}_t$ where $\tilde{K}_t$ denotes the detended capital stock per worker. Provided $\bar{\beta} = \beta(1+n_\alpha)^{1-\mu_1}(1+n_A)^{\mu_2}(1+n_w)^{\mu_3}/(1+n_p) < 1$, it is straightforward to show that a solution exists for the functional equation defined by (C.1).

The discount factor for the baseline specification is $\beta = 0.95$, which implies an annual interest rate of 5.26%. The value of β determines the steady-state capital stock per worker for the model. Given the values of η and δ, the value of β is thus consistent with the long-run behavior of other economic aggregates. See Cooley (1994, p.21). The deterministic trends are given by $n_\alpha = -0.02$, $n_w = 0.005$, and $n_p = -0.005$. To account for the presence of the irreversibility constraint $K_{t+1} \geq (1-\delta)K_t$, the elements of the capital grid denoted $\mathcal{K}$ are chosen as $\kappa_{M-j+1} = (1-\delta)^{j/n}\hat{K}$, $j = 1, \ldots, M$, where n is a positive integer. (See Sargent, 1980). Using the law of motion for capital in the deterministic steady state, $\delta = I/K - n_K$, where I/K denotes the investment-capital stock ratio and n_K is the average growth rate in the capital stock. The average investment-capital stock ratios for M&E and structures investment in total industries over the period 1963-1998 are given by 0.1524 and 0.0509, respectively. For the various capital stock measures considered in this study, n_K varies around 3.5%. Hence, the depreciation rate is taken as $\delta = 0.075$. There are 150 points in the capital grid with $n = 5$ and $\hat{K} = 100$. The stationary components of productivity and demand follow lognormal AR(1) processes with baseline (unconditional) distributions for

$\ln(A_t)$ and $\ln(\alpha_t)$ as $\ln(\tilde{A}_t) \sim N(2.5, 0.00048)$ and $\ln(\tilde{\alpha}_t) \sim N(10, 0.0049)$ and autoregressive parameters $\rho_A = 0.75$ and $\rho_\alpha = 0.5$, respectively.