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Labour, Industries and the Politics of Immigration

par Ludovic Rheault

Département de science politique

Faculté des arts et des sciences

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par

Ludovic Rheault

a été évaluée par un jury composé des personnes suivantes :

André-J. Bélanger, président

Frédérick Bastien, président (soutenance orale)

André Blais, directeur de recherche

Richard Nadeau, membre du jury

Stanley L. Winer, examinateur externe

Roxane de la Sablonnière, représentante du doyen de la FESP

Résumé

Cette thèse par articles examine les causes et conséquences économiques des politiques d'immigration du point de vue des pays receveurs. Je soutiens que les politiques d'immigration affectent la composition industrielle, et que l'immigration non-qualifiée a ralenti le développement des secteurs haute-technologie dans les pays de l'OCDE au cours des dernières décennies. Néanmoins, les gouvernements élus ont des incitatifs à accroître les niveaux d'immigration et à admettre des immigrants non-qualifiés, afin de conserver l'appui du secteur privé, et de façon à éviter les réactions négatives qui résulteraient de l'affaiblissement des industries traditionnelles.

Le premier article s'appuie sur un modèle de progrès technologique endogène et soutient que les activités de recherche des entreprises croissent avec l'offre relative en travail qualifié, et se contractent avec l'offre relative en travail non-qualifié. À l'aide de données panel sur les pays de l'OCDE entre 1971 et 2003, j'estime l'élasticité des dépenses en R&D par rapport à l'offre relative de facteurs au moyen d'un modèle OLS dynamique (DOLS). Les résultats sont conséquents avec les propositions théoriques, et je démontre que l'immigration non-qualifiée a ralenti l'intensité des investissements privés en R&D.

Le deuxième article examine la réponse des gouvernements fédéraux canadiens au lobbying des entreprises sur l'enjeu de l'immigration, à l'aide de données trimestrielles entre 1996 et 2011. J'argue que les gouvernements ont des incitatifs électoraux à accroître les niveaux d'immigration malgré les préférences restrictives du public sur cet enjeu, afin de s'assurer de l'appui des groupes d'intérêt corporatifs. Je teste cet argument à l'aide d'un modèle vectoriel autorégressif. Un résultat clé est la réponse positive des influx de travailleurs temporaires à l'intensité du lobbying des entreprises.

Le troisième article soutient que les gouvernements ont des incitatifs à gérer la sélection des immigrants de façon à préserver la composition industrielle régionale. Je teste cet argument avec des données panel sur les provinces canadiennes entre 2001 et 2010, et un devis de recherche basé sur l'approche des doubles moindres carrés (*two-stage least squares*). Les résultats tendent à appuyer l'argument principal: les provinces dont l'économie repose davantage sur des industries traditionnelles sont susceptibles de recevoir une plus grande proportion d'immigrants non-qualifiés, ce qui contribue à renforcer cette spécialisation.

Abstract

This paper-based dissertation examines the economic causes and consequences of immigration policies from the perspective of recipient countries. I argue that immigration policies affect the industry mix, and that unskilled immigration has tempered down the development of high-technology sectors during the past decades in OECD countries. Nonetheless, elected governments have incentives to increase immigration levels and to admit unskilled immigrants, in order to maintain the support of corporate interests, and to avoid the negative attention that would result from the depletion of traditional industries.

The first paper builds upon a model of endogenous technological change to argue that business research activities expand with the relative supply of skilled labour, and contract with relative increases in unskilled labour. Using panel data on OECD countries between 1971 and 2003, I estimate the elasticity of R&D outlays with respect to relative factor supplies with a dynamic OLS (DOLS) model. The empirical findings are consistent with the theory, and a key policy implication is that unskilled immigration has dampened the intensity of business investments in R&D.

The second paper examines the responsiveness of Canadian federal governments to corporate lobbying on the subject-matter of immigration, using quarterly data between 1996 and 2011. I claim that governments have electoral incentives to increase levels of immigration despite the restrictive preferences of the public, in order to secure the support of corporate interest groups. To test this argument, I make use of the vector autoregression methodology. A significant finding is the positive response of temporary worker inflows to the intensity of corporate lobbying.

The third paper argues that governments have incentives to adjust the skill composition of immigration in order to maintain the existing regional industry mix. I test this argument using panel data on Canadian provinces between 2001 and 2010, and a research design based on the two-stage least squares approach. The empirical findings are consistent with the main argument: provinces relying intensively upon traditional industries are likely to receive higher proportions of unskilled immigration, which contribute to maintain this specialization.

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List of Acronyms

2SLS	Two-stage least squares
ADF	Augmented Dickey-Fuller
ANES	American national election studies
BERD	Business expenditures in research and development
CCC	Canadian Chamber of Commerce
CES	Canadian election studies
CIC	Citizenship and Immigration Canada
DOLS	Dynamic ordinary least squares
ECM	Error correction model
G2SLS	Generalized two-stage least squares
GDP	Gross domestic product
GERD	Gross expenditures in research and development
GMM	Generalized method of moments
IRPA	Immigration and Refugee Protection Act
NAICS	North-American industry classification system
OECD	Organization for Economic Co-Operation and Development
OLS	Ordinary least squares
PNP	Provincial nominee program
PPP	Purchasing power parity
R&D	Research and development
SIG	Special interest group
VAR	Vector autoregression

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Chapter 1

Introduction

Immigration is strikingly unpopular. Asked periodically since 1992 whether the number of immigrants admitted to their country should be increased, never more than a meagre 17% of Americans and Canadians agreed with the idea. Table 1.1 shows the full distribution of answers to this survey question included in 14 recent national election studies in the United States and Canada. Although Americans are more likely to support a reduction of immigration flows than Canadians, in both countries the average respondent's preference has been persistently leaning in favour of lower levels of immigration. Such figures are rather common for Western countries. In fact, the population from 22 OECD countries was asked the same question in 2003, and 57% of all respondents said they preferred immigration levels to decrease (ISSP, 2003).[1]

Given so little public support for immigration, one might expect that electorally motivated governments would seize the opportunity to adopt restrictive policies. Bewilderingly, empirical evidence suggests the opposite. Levels of permanent residents have been waxing in the USA and Canada since the prohibitive inter-war period, as depicted in Figure 1.1. Between 1931 and 2011, annual entries of immigrants have increased by 1000% in the USA, and by 800% in Canada; meanwhile the population as a whole in both countries merely tripled in size. The pace of increase appears steady when looking south of the border, compared to the punctuated drift in Canada. Nonetheless, in both cases, levels of immigration followed an increasing trajectory during the past two decades, as highlighted by the superimposed time trends in Figure 1.1. Clearly, those trends are conflicting with the preferred policy direction among the public. The same pattern arises when combining permanent immigrants with temporary workers, as illustrated in Figure 1.2: in the USA, inflows from both categories have tripled in size in just two decades. As for European

[1] This number is the weighted proportion of respondents who said they preferred immigration flows to be reduced a little or a lot, pooling together the 22 countries from the ISSP National Identity II survey who were members of the OECD in 2003.

Table 1.1: Public Opinion on Immigration in the United States and Canada (1992-2011)

American National Election Studies (ANES)				
Survey	Increase	Same	Decrease	(Decrease – Increase)
1992	7%	38%	43%	36
1994	5	27	64	59
1996	5	31	51	46
1998	11	38	49	38
2000	9	43	45	36
2004	8	37	41	33
2008	13	36	40	27
Canadian Election Studies (CES)				
Survey	Increase	Same	Decrease	(Decrease – Increase)
1993	17%	17%	61%	44
1997	9	41	46	37
2000	14	47	35	21
2004	16	50	29	13
2006	15	55	24	9
2008	14	55	25	11
2011	11	58	28	17

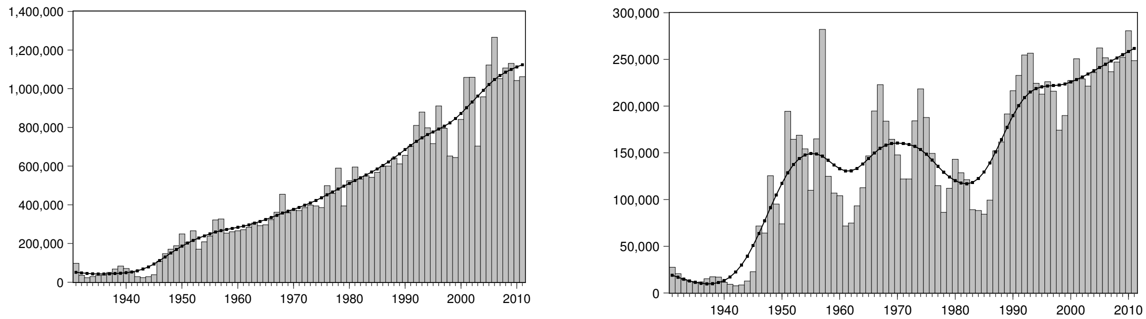
The ANES question asks "Do you think the number of immigrants from foreign countries who are permitted to come to the United States to live should be increased, decreased, or left the same as it is now?" The CES question asks "Do you think Canada should admit more immigrants, fewer immigrants, or about the same as now?" Weighted proportions for each response category are reported in the table, while the last column shows the difference between the proportions in the "Decrease" and "Increase" categories, in percentage points.

countries, which had not been traditional recipients of large-scale immigration, they too have implemented increasingly expansive policies during the past decades (Hatton and Williamson, 2005, Ch. 10; OECD, 2007, 2012).

A more suitable measure for comparisons would take into account the importance of immigration relatively to the recipient population. Figure 1.3 shows smoothed trends in the share of population growth attributable to immigration between 1955 and 2011, again for the USA and Canada. Clearly, the demographic weight of immigration has also been increasing. Inflows of permanent residents account for nearly half the growth of population

Figure 1.1: Annual Immigration Levels in the United States and Canada (1931-2011)

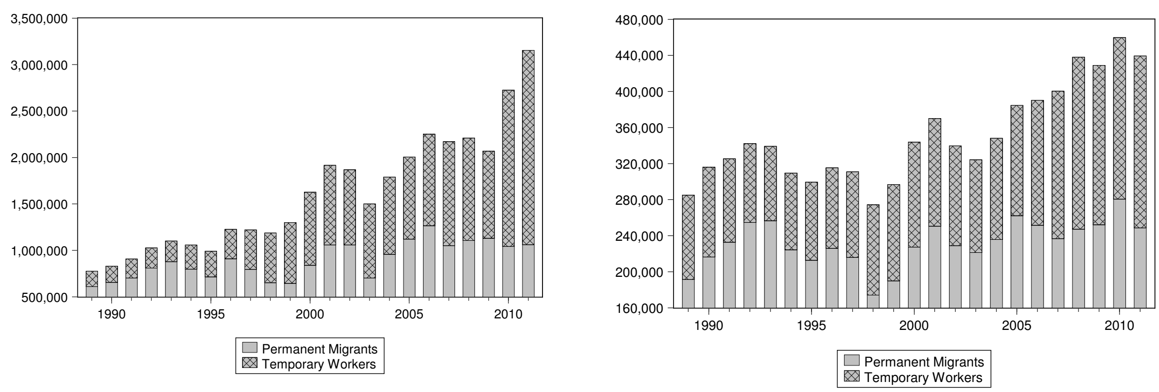
(a) United States (b) Canada



Sources: USA (2012) and CIC (2012*b*). Data for the USA exclude naturalizations under the 1986 Immigration Reform and Control Act.

Figure 1.2: Permanent and Temporary Immigration in the United States and Canada (1989-2011)

(a) United States (b) Canada

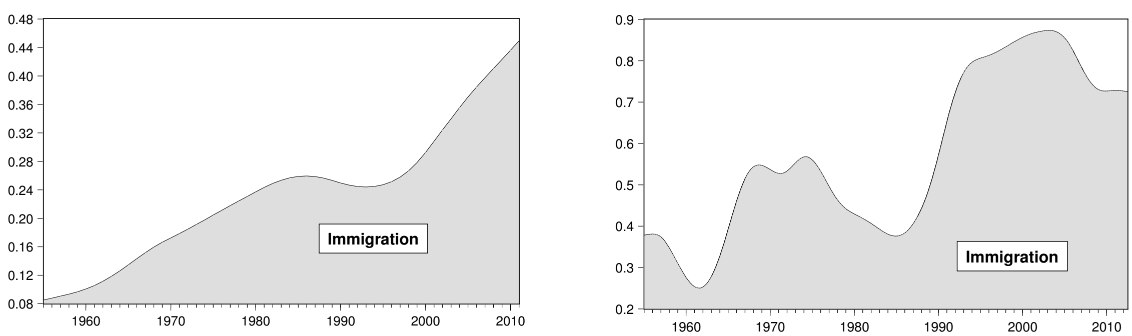


Sources: USA (2012) and CIC (2012*b*). Temporary workers data in the USA include spouses, but exclude the categories of intracompany transferees, treaty traders, and representatives of foreign information media. Canadian data for temporary workers correspond to the total number of work permits issued per year.

in the USA today, compared to a negligible role in the 1950s. In Canada, immigration as a share of population growth recently rose above 0.8, whereas it had typically stayed well below 0.5 before the 1990s. Notice that the intensity of immigration differs markedly across the two countries, American policies appearing more restrictive than their Canadian analogues. However, the magnitude of the change over time is comparable. In other words, immigration *trends* are similar across the two countries, and they are once again diametrically opposed to the wishes of the public.

Figure 1.3: Share of Population Growth Attributable to Immigration in the United States and Canada (1955-2011)

(a) United States (b) Canada



Shares are computed based on quarterly data for Canada (Canada, 2013*a*,*b*), and on fiscal year data for the United States (USA, 2012, 2013). Each series has been smoothed using a Hodrick-Prescott filter with $\lambda = 100$. The series correspond to the share of annual population change composed of immigration.

This puzzling feature of immigration politics—the discrepancy between public preferences and the direction of policies—has been singled out by several scholars focusing on Western countries (Freeman, 1995, 2002; Fetzer, 2000; Hansen, 2000; Tichenor, 2002; Menz, 2009). Arguably, representatives must have well-entrenched motivations to act the way they do, strong enough to outweigh the risk of jeopardizing their popularity among the voters who brought them to office in the first place. The broader objective of this dissertation is precisely to understand the motivations behind the management of immigration policies. In other words, a relevant scientific contribution should help to identify the stakes faced by governments when dealing with immigration, and the factors driving their paradoxical behaviour.

A cursory glance at the discourse of Canadian elected officials suggests that the answer to this puzzle is economical. According to their narrative, neglecting public opinion would be justified by the foresight of a greater woe: looming economic threats posed by oncoming labour shortages, to which immigration appears to be the sensible response. Instances of such a narrative abound in official publications. The Canadian legislative committee on citizenship and immigration recently issued a report emphasizing that "immigration is a vital component of a multi-pronged strategy to address Canada's looming demographic challenges [...]" (Canada, 2012*b*). The Minister of Citizenship and Immigration used a similar narrative in a recent annual report to parliament:

> Immigration is an integral part of Canada's economic success. [...] It is essential that Canada positions itself as a serious competitor for global talent, so that we can address labour market shortages and strengthen economic growth. To that end, our goal is to create a fast, flexible economic immigration program (CIC, 2012*a*, 1).

The 2012 federal budget also took care to mention how immigration serves the goal of "fuelling economic prosperity for Canada" (Canada, 2012*c*, 19).

This narrative appears to survive across party lines, the publications under the last Liberal government during the 38th parliament having an identical tone. For instance, the 2005 budget emphasized that "[l]ooking forward, it is essential that Canada continue to be a destination of choice for immigrants, and that newcomers to Canada are integrated into the economy and society as effectively and efficiently as possible" (Canada, 2005*a*, 307). In *A Plan for Growth and Prosperity*, the Department of Finance stressed the need to increase annual immigration levels to 900,000 by 2030 (a threefold increase compared to current levels), based on alarming demographic projections. The publication added that "[i]mmigration not only enriches Canada's diversity, it also bolsters our labour force and our prosperity", and that "Canada's openness to immigration provides an important competitive advantage" (Canada, 2005*c*, 80).[2]

Despite its forceful tone, this sort of economic narrative merely replaces one puzzle by another. As emphasized in the next section, neoclassical theory does not provide support to the claim that population growth has only benefits for the recipient economy. An increase in the rate of growth of population is expected to boost the growth in the *size* of output, but to negatively affect indicators of per capita wealth. Concisely summarized in the words of Barro (1998, 22), "[i]f the population is growing, then a portion of the economy's investment is used to provide capital to new workers rather than to raise capital per worker." Under this framework, the economic benefits of immigration appear subjective, and depend on how increasing the size of a country represents a desirable goal compared to improving economic conditions for the individuals living in that country. As for studies addressing the use of immigration to compensate for the fiscal consequences of population ageing (e.g. Auerbach and Oreopoulos, 1999; Lee and Miller, 2000; Storesletten, 2000; Mérette, 2009), they lead at best to qualified conclusions. Scholars tend to agree on the idea that, under realistic scenarios, the impact of immigration on the projected fiscal imbalance is small, once accounting for the life-cycle and the dependents of newcomers. The recent economic literature has raised other qualifications relevant for the study of the economic impact of immigration, which are reviewed in the next section. Nonetheless, there

[2]In contrast, the narrative of Presidents in the United States is somewhat more nuanced, balancing economic concerns against the need to tackle the issue of illegal immigration. Economic issues are nonetheless evoked when addressing immigration policies. For instance, in the 2013 State of the Union Address, President Obama claimed that "[o]ur economy is stronger when we harness the talents and ingenuity of striving, hopeful immigrants" (Obama, 2013).

is hardly a consensual scientific support behind the one-sided narrative of Canadian governments. It also appears unlikely that elected officials have developed their views on the basis of a sophisticated analysis of the latest scientific literature. Overall, it is probably fair to say that recent Canadian governments have been more enthusiastic than scholars about the benefits of immigration.

In this dissertation, I introduce an economic theory of immigration policies making sense of those puzzling realities. My specific objective is to examine the economic causes and consequences of immigration policies for recipient countries, while taking into account both the levels and the skill composition of immigration. I claim that yes, economic considerations matter. However, the actual motivations behind policies are more pragmatic than what elected officials admit. I argue that immigration policies have important effects on the mix of national industries, and that unskilled immigration has tempered down the development of high-technology sectors during the past decades in OECD countries. Nonetheless, elected governments have incentives to increase immigration levels and to admit unskilled immigrants, in order to maintain the support of corporate interests and to prevent the decline of traditional industries. Each part of this argument is developed in three single-authored papers that represent the core of the dissertation.

The theory is motivated by the context that developed countries are facing. OECD countries have experienced a metamorphose during the last decades. The compound annual growth rate of the skilled working-age population (with tertiary education) has been larger than 4% between 1971 and 2003 in the 21 OECD countries considered in the first paper of this dissertation. In comparison, the stocks of working-age population without tertiary education have increased annually by 0.6%.[3] As a result, traditional industries relying intensively on unskilled labour are progressively superseded by new industries more

[3]Those figures are based on the Barro and Lee (2010) data set, and are discussed in Chapter 2. An additional example is presented in Chapter 4, based on Canadian data.

adapted to the skill composition of the workforce (see e.g. Gera and Mand, 1998). Those shifting trends are consequential for the argument of this dissertation, since immigration policies also affect the supply of labour and its composition. This is why I devote considerable attention to the implications of my argument for the knowledge-based economy.

One of the main contributions of this dissertation is to emphasize a counter-intuitive impact of immigration policies. The findings of the first and third papers show that immigration can be interpreted as a policy tool slowing down the pace of the ongoing transformation of the economy. The counter-intuitive aspect of this conclusion is underscored when considering the Canadian case in Chapter 4. Indeed, Canada has implemented a point system purposely aimed at facilitating the selection of skilled migrants. Nonetheless, despite the selection of important shares of skilled migrants, immigration dampens the change that would be induced by new cohorts of native population alone. I also provide a rationale explaining why policy-makers have incentives to accept this situation, opening the door to future research on the topic.

A second contribution is the reliance on original data to examine the efforts by the corporate sector to influence immigration policies, and the resulting policy response. So far, those channels of influence have remained largely opaque to the public eye. I overcome this limitation by making use of fine-grained data on lobbying activities in Canada, made available following the recent implementation of legislations aiming at a greater transparency in public affairs. The findings contribute to a literature that has previously emphasized the influence of the corporate sector on immigration policies, yet oftentimes without sufficient quantitative evidence to support claims of causal inference.

A third contribution of this dissertation is the distinction being made between sectors of the recipient economy, and between the skill levels of immigrants. This setup enables me to reach conclusions that are more specific than that of studies neglecting either one of those dimensions. For instance, the distinction between industries relying upon different factor intensities helps to understand how immigration may affect not only aggregate output, but also the specialization of production in the recipient economy. The third paper (Chapter 4) proposes a detailed outlook on this relationship, which has very few counterparts in the existing literature.

Finally, Chapter 2 contributes to a salient debate in the recent economic literature on innovation and technological change. This chapter looks at the impact of labour resources on the intensity of high-technology industries and business R&D. I use the empirical estimates to derive key implications for immigration policies, but the findings are even broader in scope. Indeed, prominent scholars have recently brought forth the idea that population growth is beneficial for technological change (Kremer, 1993; Jones, 1995; Jones and Romer, 2010), which represents a major shift compared to neoclassical theory. However, this idea is not completely consistent with other models in the literature, as I show in the next section, and it stumbles on the fact that technologically advanced countries tend to have lower rates of population growth (see Chapter 2). The findings of Chapter 2 challenge the optimistic view that population benefits innovation, based on robust empirical evidence, and after emphasizing the importance of taking into account the skill composition of labour. Moreover, I make use of simulations to estimate the effect of immigration policies on business R&D intensity, an endeavour rarely undertaken before.

The rest of this introductory chapter is organized as follows. It shall be noted that, given the format of this paper-based dissertation, the core chapters already comprise their own literature reviews and theoretical sections. To avoid redundancy, the next section focuses on pieces of literature that have not been addressed thoroughly in the papers, but that are relevant to understand the overarching argument of the dissertation. Afterwards, I introduce a summary of the theory, emphasizing the linkages between the three papers.

1.1 Literature Review

This dissertation builds upon two main bodies of literature. The first originates from the field of economics, and concerns the impact of immigration. The second pertains mostly to the field of political science, and deals with the motivations of policy-makers involved in the management of immigration. Since understanding the motivations behind immigration policies requires knowledge of the consequences of those policies, the two streams of literature can hardly be taken in isolation without missing important elements of the political economy of immigration. A distinctive feature of this dissertation consists precisely of piecing together those bodies of knowledge.

1.1.1 The Impact of Immigration on Recipient Countries

Several notions useful to study the economic impact of immigration have been introduced elsewhere (see e.g. Borjas, 1994, 1995, 2000; Hatton and Williamson, 2005; Grubel, 1994), largely inspired by fundamental principles of neoclassical economic theory. Even though covering those notions may sound pedantic, it appears relevant to expose them in order to justify the modelling choices made in the subsequent section. Unless noted otherwise, the following lines are based on textbook theories, without explicit references to the literature.

Consider a simple representation of the national economy based on a Cobb-Douglas production function with two factors of production and constant returns to scale:

$$Y = K^{\alpha} L^{(1-\alpha)}, \tag{1.1}$$

where Y is output, K means the stocks of physical capital, L means labour, and where the parameters α and $(1-\alpha)$ represent the productivity of each factor. The marginal product of labour corresponds to $\frac{\partial Y}{\partial L} = (1-\alpha)\frac{Y}{L}$, so that the elasticity of output with respect to L corresponds to $(1-\alpha)$. The value of $(1-\alpha)$ is commonly interpreted as the labour share of income (i.e. the share of national income in wages). For illustrative purposes, the average value of the labour income share for the sample of 21 countries considered in Chapter 2, between 1971 and 2004, is approximately 0.7 (OECD, 2011*b*). This value exhibits little variation over time, and can be treated as a constant for simplicity. Based on this simple framework, it follows that a 1% increase in the supply of labour, for instance caused by immigration flows, is expected to generate a 0.7% increase in output.

On the other hand, the second derivative of the production function with respect to L gives the impact of a change in L on its own marginal product. If we consider the common assumption that factors are paid their marginal product, this amounts to say that the second derivative measures the effect of labour supply on wages. The elasticity of wages with respect to L corresponds to $-\alpha$ in the model introduced above. To show this, one may simply express the second derivative of the production function with respect to L in terms of an elasticity:

$$\begin{aligned} \frac{\partial^2 Y}{\partial L^2} &= -\alpha(1-\alpha)K^{\alpha}L^{(-1-\alpha)}, \\ &= -\alpha\frac{\frac{\partial Y}{\partial L}}{L}. \end{aligned} \tag{1.2}$$

Therefore, still considering the example value $(1-a) = 0.7$, a 1% increase in the supply of labour caused by immigration flows is expected to pull down wages by –0.3%. Under this baseline static framework, such a result arises whenever the initial production function has decreasing returns in labour: even though the additional workers increase the size of the economy, they do so less than proportionally. Consequently, measures of production *per* worker are negatively affected.

The conclusions are similar when considering the Heckscher-Ohlin (HO) model in the subfield of international economics (see Ohlin, 1967; Grubel, 1994; Hatton and Williamson, 1994; O'Rourke, Taylor, and Williamson, 1996; Taylor and Williamson, 1997; Krugman and Obstfeld, 2002; Rogowski, 2006). The difference is that both emigration and recipient countries are considered in the framework. International labour movements are predicted to occur from labour-abundant countries toward labour-scarce countries, wages being initially higher in the latter than in the former. Such an implication is roughly consistent with the current patterns of international migration, flows of labour being oriented largely from labour-abundant developing countries toward labour-scarce developed countries (Hatton and Williamson, 2005, 206-211). According to the HO framework, such movements ultimately lead to a convergence in factor prices: wages in recipient countries are affected downward, and conversely for emigration countries. As can be seen, the comparative static of interest for recipient countries is the same as the one just described in the previous paragraph.

The seminal Solow-Swan growth model leads to consonant implications, this time using a dynamic framework (Solow, 1956; Swan, 1956; Barro and Sala-i-Martin, 2004). In this model, the objective is to understand the behaviour of per capita values in a steady state. First, capital is accumulated through investments, so that the expression $\dot{K} = sY$ is used to denote the change in capital stocks, where s is the share of income in savings, assumed to be constant, and where depreciation is omitted for simplicity. The rest of the notation is similar as before. Second, the capital-labour ratio is denoted $k = \frac{K}{L}$, and output per worker is $y = \frac{Y}{L}$, such that the aggregate production function can be expressed as $y = k^{\alpha}$. The model can be solved using the familiar analytical techniques described in Solow (1956), Mankiw, Romer, and Weil (1992), Jones (1997), and Barro and Sala-i-Martin (2004).

Taking logs and derivatives on both sides of the expression $k = \frac{K}{L}$ yields

$$\frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{L}}{L} = \frac{sY}{K} - \frac{\dot{L}}{L}. \tag{1.3}$$

Following the usual convention, let n denote the rate of growth of labour. Rearranging (1.3) and making use of the identity $\frac{y}{k} = \frac{Y}{K}$, the growth model can be expressed in the simplified form

$$\dot{k} = sy - nk = sk^{\alpha} - nk \tag{1.4}$$

The steady-state value is reached when the time derivative of the capital-labour ratio $\dot{k}$ is constant and equal to zero. Therefore, the equilibrium value of k in the steady state corresponds to:

$$k^* = \left(\frac{s}{n}\right)^{\frac{1}{1-\alpha}}. \tag{1.5}$$

Since $y^* = k^{*\alpha}$, then the elasticity of the steady-state level y^* with respect to n becomes $-\frac{\alpha}{1-\alpha}$.

Notice the difference with what has been said previously. The elasticity of wages with respect to L was said to be $-\alpha$ under the static framework, but the elasticity of y^* with respect to n is now $-\frac{\alpha}{1-\alpha} < -\alpha$. The asymmetry happens because level variables such as output and capital grow at the same rate as population in the Solow-Swan model, on a one-for-one basis (the capital-labour ratio being constant in the steady state, this has to be case) (Barro and Sala-i-Martin, 2004). Using the same example values as before, per capita output absorbs a permanent change of 1% in the rate of growth of population n by decreasing toward a new steady state level, $\frac{0.3}{0.7}$% lower than the initial one, all else equal. Overall, the implications are similar as before, except that the reasoning is in growth terms. Although increasing the rate of growth of population through immigration policies is expected to positively affect the growth rate of output, on the other hand this negatively affects the steady-state value of output per capita. This impact on per capita wealth is transitory—in the Solow-Swan model, the long-run rate of growth of y depends entirely on an exogenous parameter, technological change (Jones, 1997; Barro and Sala-i-Martin, 2004).

At least three qualifications to the neoclassical model introduced above are of particular relevance in order to understand the economic impact of population, hence of immigration. Firstly, the skills and experience of immigrants matter, since those represent a form of capital embedded in labour, often called human capital. Consequently, a common extension to the model consists of contrasting the case where immigrants enter the recipient economy without capital, against the case where immigrants bring capital with them (see Barro and Sala-i-Martin, 2004, Ch. 9, for a full exposition). For instance, Grubel (1994) shows that if immigrants carried some form of capital (either physical capital or human capital), this would offset to some extent the negative impact of an increase in labour supply on the capital-labour ratio. Put simply, migrants would have to bring capital in such quantity that the capital-labour ratio remains the same as before immigration took place in order to leave per capita values unaffected. The augmented model including human capital has led to a policy implication that is probably consensual among both scholars and policy-makers: skilled migrants (or wealthy migrants) are deemed more desirable, since their capital mitigates the depressive impact of immigration on per capita outcomes (see Borjas, 1995). This provides a rationale for "point systems" giving priority to skilled migrants, such as the one currently used in Canada.

Secondly, the mix of industries in the recipient economy may adjust in response to inflows of foreign labour. This requires making the distinction between sectors of the national economy. The seminal Rybczynski (1955) theorem, for instance, implies that labour-intensive industries may benefit disproportionately from immigration flows, whereas capital-intensive industries would be undermined. The idea can be extended by further considering the distinction between types of immigrants, as I do in this dissertation. Hanson and Slaughter (2002) build upon this idea to argue that the mix of industries in the US States adjusts to immigration flows from different skill levels. They also invoke the factor price equalization theorem to support the idea that wages equalize across states. This is an important qualification to the basic neoclassical framework introduced above, which did not make the distinction between sectors. In a nutshell, although immigration is expected to boost the size of the recipient economy, this increase may be driven by specific industries, depending on the skill composition of immigrants.

Thirdly, the advent of endogenous growth theory (or new growth theory) helped to address a limitation of the Solow-Swan model. The latter treats technological change as an exogenous factor, while new growth theory aims at explaining its sources (Jones, 1997; Barro and Sala-i-Martin, 2004). This specific branch of the literature is addressed in Chapter 2. For the moment, it is worth repeating how recent works have stressed that population growth is beneficial for technological change, sometimes elevating this argument to the status of "stylized fact" (Jones and Romer, 2010). Yet, such a conclusion is primarily based on Jones (1995), in which the skill composition of labour is not addressed, just like the initial neoclassical model presented above. When making the distinction between types of labour, the theoretical findings are much more nuanced, if not pointing to opposite conclusions (see Romer, 1990*a*; Grossman and Helpman, 1991; Acemoglu, 2002). Assessing the implications of models of endogenous innovation is of paramount importance for the study of immigration policies, which is why I take into account those developments in the first paper of this dissertation.

As for the empirical literature, a large portion of it has been devoted to the impact of immigration on wages, one of the key implications of the neoclassical framework. The conclusions are often largely affected by the set of assumptions under consideration, or the empirical specification. In their review of the American literature, Greenwood and McDowell (1986) express skepticism regarding the magnitude of the impact of immigration on wages (see also Friedberg and Hunt, 1995). They also point to the fact that international capital flows may counterbalance the effect of immigration. In an oft-cited case study, Card (1990) also concluded that the impact of immigration on wages is small. Challenges to this sort of conclusions have emerged in Borjas, Freeman, and Katz (1996), who questioned the empirical methodology used to assess the labour market impact of immigration. In a recent study, Borjas (2003) estimates that the elasticity of wages with respect to immigration flows is around –0.3, close to the example used above (see also Borjas, 2005; Aydemir and Borjas, 2007; Brücker, Jahn, and Upward, 2012). However, recent meta-analyses concluded that many empirical studies find the labour market impact of immigration to be small in magnitude (Longhi, Nijkamp, and Poot, 2005, 2008).

In contrast, empirical studies on adjustment mechanisms to immigration, or else on the implications for technological change, are very scarce. There is, however, a series of empirical papers addressing the relationship between factor endowments more generally and output mix (e.g. Harrigan, 1995, 1997; Bernstein and Weinstein, 2002), as well as a few studies focusing on immigration more specifically (Hanson and Slaughter, 1999, 2002; Lewis, 2003, 2005; Gandal, Hanson, and Slaughter, 2004). In general, the findings of those papers are rather supportive of the idea that the national industry mix adjusts to changes in labour supply. On the other hand, Davis and Weinstein (2002) use a Ricardian model of international factor flows and conclude that immigration has a negative impact on multi-factor productivity, a measure of technological change. Hunt and Gauthier-Loiselle (2010) reach an opposite conclusion, although they focus solely on skilled immigration. Overall, and although there is a solid ground to expect immigration to affect the industry mix and the type of economic activities undertaken nationally, this is precisely the branch of the literature for which most research is left to be done, both theoretically and empirically.

1.1.2 The Determinants of Immigration Policies

Knowledge of the consequences of immigration for the recipient economy provides a useful starting ground for explaining the motivations of social actors and policy-makers. An early argument raised in the political science literature builds upon the key neoclassical expectation that immigration constrains the growth of wages. Under this explanatory framework, the corporate sector benefits from expansive immigration policies, which drive down labour costs, whereas workers are thought to be negatively affected. As for governments, they seek to find a suitable compromise amid this clash of interests. Several works have brought forth explanations along those lines, notably in the subfield of comparative politics (Freeman, 1979, 1986, 1995, 2002; Lee, 1998; Joppke, 1999). This approach emphasizing the political influence of corporate actors is interesting because it can account for the observed discrepancy between public opinion and current immigration trends.

To a large extent, this literature has been hitherto qualitative. Scholars have relied intensively upon case studies (see e.g. Freeman, 1995; Joppke, 1999; Tichenor, 2002; Menz, 2009, 2010). In fact, because of the difficulty of observing the influence of interest groups on policy-makers, the relevant data needed for quantitative analysis are often simply unavailable. A rare quantitative study focusing on the idea that private firms exert influence on immigration policies came from Facchini, Mayda, and Mishra (2011). They use lobbying expenditures by industry in the United States, and test whether those are related to the number of temporary work visas. Their findings give credence to the claim that corporate lobbying positively affects the levels of immigration. Moreover, a study from Nicholson-Crotty and Nicholson-Crotty (2011) examines the relationship between the intensity of labour-intensive industries and the openness to immigration in the United States, again with conclusive results. The theory introduced in the next section contributes to this literature, by proposing a model that is consistent with those existing findings.

Such a line of argument is enshrined in an even broader literature on special interest politics (Baron, 1994; Grossman and Helpman, 1996, 2001; Prat, 2002) and lobbying (Austen-Smith, 1995; Grossman and Helpman, 2001; Besley and Coate, 2001; Leech et al., 2005; Baumgartner et al., 2009). Despite a lack of systematic empirical support, the idea that special interest groups affect the shaping of public policies is appealing to many. Summaries of the existing corpus can be found in Schlozman and Tierney (1986), Baumgartner and Leech (1998), Mueller (2003, Ch. 20), and Stratmann (2005). Recent theoretical contributions emphasize that policy-makers have rational incentives to cater to interest groups, often at the expense of voters' preferences (Baron, 1994; Grossman and Helpman, 2001). Within this literature, trade policies have received wide attention, national industries being thought to have a preference for protectionism (Brock and Magee, 1978; Magee, Brock, and Young, 1990; Grossman and Helpman, 1994). Although specific conclusions are sometimes the object of debate (see e.g. Milner, 2002), these works tend to agree on the relevance of considering the influence of national interest groups in the policy-making process.

Finally, the theoretical model introduced in this dissertation also bears a resemblance to other works in the subfield of international political economy (IPE). For instance, Rogowski (1989) built upon the Stolper-Samuelson theorem in international economics to bring forth a theory of trade policies. His book bridges literature from both economics and political science, and makes use of predictions stemming from economic theory to explain the preferences of national actors over trade policies. Alternative theoretical arguments have been proposed by considering predictions based instead on the Ricardo-Viner theorem, again to explain trade policy outcomes (Irwin, 1994, 1996; Alt and Gilligan, 1994). This has led to a rich literature on trade policies in IPE, summarized in Alt et al. (1996). The approach developed in the next section is reminiscent of those works, except that I focus on immigration policies.

1.2 An Economic Theory of Immigration Policies

I develop the theoretical argument of this dissertation separately in each of the three central papers. However, this section introduces the key concepts helping to link the pieces of the argument together, while trying to avoid redundancy with the following chapters. The theory comprises two important stages. First, I examine the economic consequences of immigration for the mix of national industries. I then make use of the conclusions to derive realistic assumptions regarding the preferences of industries over immigration policies. Second, I examine the motivations of governments when managing both the levels and the skill composition of immigration.

To begin with, I consider a small open economy that is composed of more than one sector. For the purpose of modelling, it is sufficient to consider two sectors. The first represents a traditional, low-technology industry, which is assumed to rely intensively upon unskilled labour. I use the label X to denote the output of that industry. In contrast, the second sector represents a high-technology industry, assumed intensive in skilled labour. Its output is labelled Z. Consistent with endogenous growth models, I suppose that intentional business expenditures in R&D take place inside the high-technology sector. Those expenditures represent the source of endogenous technological change.

I also consider the distinction between two types of labour supplies, based on their skill level. Throughout this dissertation, unskilled labour will be denoted L and defined as the working-age population without university education. Skilled labour will be denoted

H and represents the working-age population with university education.[4] Flows of immigrants will be categorized the same way, based on their educational attainment. Limiting myself to those two factors, the relationship linking labour supplies with the two industries can be depicted concisely by imposing factor market-clearing conditions:

$$\begin{bmatrix} L \\ H \end{bmatrix} = \begin{bmatrix} a_{X,L}X + a_{Z,L}Z \\ a_{X,H}X + a_{Z,H}Z \end{bmatrix} \tag{1.6}$$

where the $a_{i,j}$s represent input coefficients—i.e. technology parameters indicating the portion of industry output attributable to each factor of production.[5]

As discussed in Chapters 2 and 4, the Rybczynski theorem can be used to derive expectations regarding the impact of immigration on the national industry mix. Namely, unskilled immigration is expected to benefit the labour-intensive industry X disproportionately, and to undermine the sophisticated industry Z. Skilled immigration, on the other hand, is expected to have the opposite impact. This means that national industries are likely to form opposite preferences over the skill composition of immigration, a distinction that is often overlooked in existing works on the political economy of immigration. The implications for technological change are further addressed in Chapter 2.

I make use of this setup to make two assumptions regarding the preferences of national industries over immigration. First, holding constant *levels* of immigration, industry X should naturally form a preference for unskilled migrants, whereas industry Z should prefer skilled migrants. This stems directly from the implications of the Rybczynski theorem. Second, and holding constant the *skill composition* of immigration, both industries would

[4]More specifically, I make use of indicators based on "post-secondary" educational attainment in Chapter 2, in order to achieve international comparisons. In contrast, the measures of Chapter 4 are based on the completion of a university degree.

[5]Note that in Chapter 2, I will consider an additional factor, capital. For simplicity, I now concentrate on labour resources only.

prefer expansive inflows of foreign labour. This follows from the more common implications of the neoclassical model: as long as none of the two industries is negatively affected by the policies, larger levels of immigration are expected to constrain the growth of labour costs in the economy as a whole. Of course, the last statement would be even more compelling in a context of imperfect competition, where firms are not indifferent to the size of their activities and have strong incentives to view immigration as a means to increase net profits. For the purpose of this study, I will assume that markets are competitive enough for the theorems of international economics to hold, but not enough to make firms completely indifferent about their size.[6]

Switching to the political dimension, I consider that governments face a two-sided pressure from the corporate sector when managing immigration. Each of the two industries seeks to increase the inflows of foreign workers in the national economy, but more specifically, each prefers inflows from the skill category advantaging them most. Thus, my argument is that governments responsive to corporate interests will use policy tools at their disposal not only to increase the overall flows of immigrants, but also to maintain the balance in the skill composition of the labour force.

I address the decision-making of governments by considering the issue of immigration *levels* separately from the issue of the *skill composition* of immigration. First, I seek to explain why electorally motivated governments tend to increase the overall levels of immigration, despite the presence of a public preferring restrictive policies. To formalize this argument, I propose to depict the preferences of the average voter as a function of

[6]The reason for this simplification is twofold. First, I wish to keep the presentation of the argument as non-technical as possible. Second, if I were to take into consideration imperfect competition (e.g. oligopolistic structures), this would require a treatment that far exceeds the scope of the dissertation, and would divert the attention away from the topic of immigration policies per se. Throughout the dissertation, I provide empirical evidence showing that industries do hold preferences consistent with my expectations. Moreover, an instance of imperfectly competitive markets is already considered in Chapter 2.

both policy positions and perceptions of party image. Using the tools of decision theory, I represent the utility function of the average voter associated with the re-election of the incumbent government as

$$U = f(c) - (x - v)^2, \tag{1.7}$$

where $f(c)$ is an increasing function of c, a variable capturing the efforts devoted to advertise the party image, where x is the actual level of immigration, and where v is the preferred level of immigration of the average voter. The expression $-(x-v)^2$ is the familiar quadratic utility loss function associated with the distance between the voter's ideal point and the policy choice, which is used in proximity models of vote choice (Downs, 1957; Riker and Ordeshook, 1968; Merrill and Grofman, 1999).

Based on the data introduced at the very beginning of this chapter, it is fair to say that current immigration policies x tend to differ from the preference v. To explain this discrepancy, and building upon the literature mentioned in the previous section, I assume that industries are exerting pressure on governments to obtain expansive flows of immigration, provided that the skill composition of newcomers is acceptable to all sectors. In turn, governments are willing to trade unpopular policy concessions inasmuch as industries are able to offset the potential loss of support from the average voter. Concretely, this means that corporate interests must contribute to the image of the incumbent in return for policy concessions, for instance by making political donations. Let s represent the intensity of the support that industries are willing to offer for each unit of y, where y denotes the distance $|x - v|$ between actual policies and the average voter preference. The efforts devoted to advertise party image, formerly defined as c, now correspond to sy. Therefore, the utility of the average voter can be reexpressed as

$$U = f(sy) - y^2. \tag{1.8}$$

Governments optimize their re-election prospects by maximizing the utility of the average voter with respect to the new choice variable y. This means that they will shift from the average voter's ideal point until the marginal benefit of the corporate sector's contribution to party image, captured by $f(sy)$, equals the marginal loss resulting from unpopular policies. Although the subfunction f is implicit, it appears realistic to assume that it respects the Inada conditions as long as efforts to improve party image exhibits decreasing returns. This means that the model should have an interior solution representing a trade-off between the policy preference of industries and that of the average voter. Chapter 3 extends this model by considering that the intensity of lobbying efforts by industries on the subject-matter of immigration is an indicator of s, the willingness to trade electoral support for policy concessions. I also consider that governments may use both permanent and temporary immigration.

Second, I turn my attention to the skill composition of immigration. I argue that when dealing with the skills-based selection of immigrants, governments take into account the expected impact on the national industry mix. In line with the two-industry setup introduced above, a key expectation is that the intensity of unskilled immigration benefits the traditional industry, but hurts the high-technology industry. Conversely, the intensity of skilled immigration advantages the high-tech industry at the expense of the traditional sector. I contend that elected governments have incentives to adjust the intensity of unskilled immigration such that the loss to both industries is minimized. The reasoning behind this model is consistent with the previous part of the argument. Minimizing the loss of each industry ensures that governments keep the support of corporate interests. Moreover, I argue in Chapter 4 that governments have incentives to avoid the negative attention that would result from the shrinking in size of an industry.

I represent the new problem by taking the absolute levels of immigration as given. The government chooses the proportion of unskilled immigrants by minimizing the loss that each of the two industries incurs from inflows of their least preferred type of immigration. This is equivalent to say that the government maximizes a weighted sum of quadratic utility losses. Letting m denote the proportion of immigrants in the unskilled category, the objective function of the government becomes:

$$\max_m U = -(1-m)^2 X - m^2 Z. \tag{1.9}$$

The problem can be easily solved from the first-order condition

$$\begin{aligned} \frac{\partial U}{\partial m} &= (2-2m)X - 2mZ = 0, \\ m^* &= \frac{X}{X+Z}. \end{aligned} \tag{1.10}$$

Moreover, the second order partial derivative $(-2X - 2Z)$ is unambiguously negative as long as the industry outputs X and Z are positive, confirming that the solution is a maximum. In short, this means that governments are expected to adjust the intensity of unskilled immigration proportionally to the existing intensity of traditional industries.

Notice that under this explanatory framework, the implementation of selection mechanisms prioritising skilled migrants such as point systems can be viewed as the consequence of the ongoing long-term trends in the skill composition of the native labour force. As emphasized earlier, OECD countries have experienced a radical transformation during the past decades, the stocks of skilled labour having considerably increased in intensity. Those trends have in turn transformed the specialization of production, which, according to the last part of the theory, explains that policy adjustments have been made to increase the inflows of skilled migrants. However, since the theory suggests that governments take into account the existing make-up of industries, the policy response remains biased toward the status quo. In other words, even though demographic trends favour the industries relying intensively on skilled labour, I argue that policy-makers are also responsive to the preferences of traditional industries, which still account for the major part of national production (see Chapter 4). Therefore, a predicted consequence of immigration policies is to slow down the growth in the intensity of high-technology industries, contrarily to what is sometimes thought. This implication is highlighted in Chapters 2 and 4.

Even though this theory of immigration policies does not drain out the whole set of implications that immigration may have, it builds upon some of the most promising literature, and highlights previously overlooked relationships. Moreover, I pay considerable attention to the distinction between industries, and between the skill levels of immigrants. Those features enrich the argument, compared to an approach that would focus solely on the macro consequences of immigration based on a single-sector model of the economy. As emphasized in the three core chapters and in the conclusion to this dissertation, the argument also opens the door to interesting lines of future research.

1.3 Structure of the Dissertation

A few words are required to introduce the specific format of a paper-based dissertation. Even though all efforts have been undertaken to harmonize the following three chapters, I should point out that each of them must be entirely understandable without the whole context. In other words, the following chapters are three stand-alone papers.[7] This means that I cannot always establish connections with other parts of the central

[7] In particular, the first paper (Chapter 2) has been revised after receiving comments from reviewers during the submission process to academic journals. This chapter initially focused entirely on immigration, but the final version now considers labour inflows more generally. The reviewers agreed that this would increase the scope of the conclusions. However, this paper proposes a practical approach to estimate the impact of immigration on private expenditures in R&D, based on plausible assumptions, as is emphasized in the policy implications section of Chapter 2.

argument. Nonetheless, this introductory chapter should have helped to underscore the common thread between the papers.

The first paper (Chapter 2) of the dissertation examines the economic consequences of labour force composition in OECD countries. I introduce the model that also serves as a foundation for the argument of the subsequent papers, emphasizing the connections between labour composition and industry mix. The empirical section presents estimates of the elasticity of business expenditures in R&D with respect to relative factor supplies, using a dynamic ordinary least squares (DOLS) model for cointegrated panel data. I then make use of simulations to assess the impact of immigration policies on the intensity of business R&D, after showing that the empirical results are robust to endogeneity. The main contribution of this paper is to emphasize an overlooked implication of policies affecting the skill composition of labour such as immigration, namely the impact on R&D, a primary source of technological change. The findings illustrate that, counter-intuitively, the typical immigration policy in OECD countries tends to hamper the intensity of business expenditures in R&D, and has little effect on the levels of those expenditures.

The second paper (Chapter 3) shifts the focus toward the policy side of the argument. I make use of data on corporate lobbying to examine the responsiveness of Canadian immigration policies to pressures from industries. The theoretical model emphasizes the motivations of incumbent governments to shift from the preference of the average voter in response to corporate lobbying. I consider both economic migrants and temporary workers, the two categories allowing governments to customize the skill composition of immigration. To test the model empirically, I make use of the Vector Autoregression (VAR) methodology and take into account the interrelatedness between the two types of immigration flows. The findings demonstrate the positive response of temporary worker inflows to corporate lobbying, even after accounting for the part of the temporary foreign worker program that is market-driven. In contrast, the results are less conclusive when considering permanent immigrants. Chapter 5 discusses the broader implications of those findings.

The third paper (Chapter 4) takes a more concrete look at the skill composition of immigration in Canada. I argue that governments have incentives to manage the composition of immigration as a function of the regional industry mix, based on rational expectations regarding the consequences of immigration flows. Detailed industry data are used to construct indicators measuring the prevalence of low-technology sectors across provinces. I then rely upon the two-stage least squares methodology in order to estimate both sides of the relationship between industry mix and the skill composition of immigration. The results are consistent with the theory. Provinces where low-technology industries are more prevalent tend to receive higher proportions of unskilled immigrants. I also find that the causal relationship works the other way around, supporting the results of Chapter 2. An exogenous increase in the proportion of unskilled immigrants stimulates traditional industries, at the expense of the high-technology sector.

Chapter 2

The Impact of Labour Resources on Business R&D

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Abstract

This paper examines empirically the impact of labour resource composition on private research and development (R&D). I consider a model in which a sector of the economy, intensive in skilled labour, produces technological change endogenously through intentional R&D activities. Provided factor complementarity, the model predicts that a relative increase in the supply of unskilled labour leads to a contraction of the private research sector, whereas a relative increase in the supply of skilled labour has the opposite effect. Those expectations are tested using a panel data set of OECD countries (1971-2003). I develop new empirical models in order to assess the elasticity of R&D outlays with respect to factor supplies, distinguishing between relative endowment effects and scaling effects. Overall, the results are consistent with theoretical expectations, and stylized policy implications are discussed. This study brings forth an important qualification to the conclusions of recent papers emphasizing a positive relationship between population and innovation. The findings suggest that business R&D can thrive with a slow growing population, notably when the intensity of unskilled labour declines, as was the case during the past decades in OECD countries.

A recent stream of literature has challenged traditional views regarding the economic impact of population, on the ground that faster rates of population growth stimulate technological change, hence economic growth (see e.g. Kremer, 1993; Jones, 1995; Jones and Romer, 2010). This contrasts with the expectations stemming from neoclassical models. Production functions with decreasing returns in labour imply that a waxing working-age population boosts the total quantity of output, but adversely affects per capita outcomes such as wages or output per worker. Solow's growth model yields similar implications, from a dynamic perspective, by showing that a rise in the rate of population growth leads to a dilution of the capital-labour ratio (Mankiw, Romer, and Weil, 1992; Barro, 1998). However, under such a framework, long-run economic growth is unaffected by population, since it depends on an exogenous rate of technological change. By placing people as the source of new ideas, models of endogenous innovation seem to have begotten a drastic revision of our knowledge regarding the economic role of demographic variables.

Even so, I show in this paper that considering population as a stimulus for innovation is misleading. My aim is to look at the implications of labour resource composition for business R&D[1]—the source of endogenous technological change. I consider a model along the lines of Grossman and Helpman (1991, ch.5), where intentional R&D activities take place within a high-technology sector, intensive in skilled labour compared to a low-technology sector. As long as factors are not close substitutes, the Rybczynski theorem implies that a relative increase in the supply of unskilled labour leads to an expansion of traditional activities, and to a dampening of research efforts. A disproportionate rise in the supply of skilled labour leads to the opposite impact. I then devise panel data estimators allowing me to distinguish between scaling effects (resulting from proportional increases in factor

[1]Although the term "R&D" without adjective is used in the text to increase readability, the paper focuses exclusively on R&D in the private sector, i.e. excluding R&D activities funded by governments. A conceptual definition of R&D activities is introduced in the theoretical section. Business R&D expenditures are considered in this paper as a measure of the magnitude of those activities.

supplies) and Rybczynski effects (resulting from disproportionate increases in a specific type of labour). Empirical data on OECD countries (1971-2003) yield support to the idea that skilled and unskilled labour supplies have opposite effects on the intensity of business R&D. Those findings raise an important qualification to the broader idea that population boosts innovation. In fact, population growth may actually slow down private research efforts, depending on the change it induces in the mix of labour resources.

It shall be noted that, from a theoretical perspective, the consequences of demography for endogenous technological change are contingent on assumptions regarding the factors used in the research sector. Authors concluding that innovation is positively related to the rate of growth of population consider labour as the input in research labs (Kremer, 1993; Jones, 1995; Jones and Romer, 2010). (In earlier models, the flow of new ideas produced through private R&D has also been modelled as an increasing function of labour supply per se (e.g. Boserup, 1981; Romer, 1986).) However, conclusions are affected whenever one distinguishes labour types. When skilled labour is considered as the main input in the R&D sector (as in Romer, 1990*b*,*a*; Grossman and Helpman, 1991, ch. 5), it follows that a rise in the supply of unskilled labour may either have positive or negative consequences for the pace of technological progress, whereas increasing the supply of skilled labour would lead to benefits in terms of faster innovation.[2] Those last models build upon realistic assumptions, if one agrees with the idea that R&D requires specialized skills to begin with. Moreover, those implications seem a priori more congruous with the empirical fact that technologically advanced countries typically had relatively low rates of population growth in the past decades. As for the first generation of studies on endogenous innovation (induced innovation theory), it paid a great deal of attention to the impact of factor prices on incentives to invest in research (e.g. Samuelson, 1965; Drandakis and Phelps, 1966;

[2]See also Peretto (1998) for an account of the relationship between population growth and R&D under alternative assumptions.

Binswanger and Ruttan, 1978). Yet this line of research was often devoted to the resulting bias in technological change (for example, whether a relative increase in the price of labour induces labour-replacing innovation) rather than the impact of resource composition on total R&D outlays.

Following on the discussion above, making the distinction between skill levels appears crucial when studying the impact of labour supply on private R&D. Theoretical findings may be considerably altered by the underlying assumptions regarding the inputs used in research. Empirical studies would also benefit from making this distinction. Furthermore, applied empirical studies have rarely considered synchronously both the scaling effects on R&D resulting from the growth in factor supplies (the effect of the size of the economy on R&D outlays), and the effects of changes in the intensity of a factor. While addressing the impact of resource composition on R&D, this paper considers not only the distinction between skilled and unskilled labour, but also the distinction between scale effects and relative endowment effects.

The paper is organized as follows. The following section develops the theoretical model. Afterwards, I introduce the data and methodology. Panel unit root and cointegration tests are then conducted, before presenting empirical estimates. Next, I discuss exogeneity issues and policy implications. A final section concludes.

2.1 Theoretical Background

The purpose of this section is not to develop a new theory of endogenous technological change, but rather to rely upon existing models in order to stress expectations regarding the impact of labour supply on R&D. I consider a model along the lines of Grossman and Helpman (1991, ch.5, Section 3), which rests upon two key ideas. The first is that R&D is an activity requiring intensive use of skilled labour (in contrast with models in which labour in general is assumed to be the input in the research sector). The second idea is that not all industries or sectors of an economy contribute equally to the development of new technologies. In the lines that follow, a model is stressed in which a sector of the economy is assumed to enjoy favourable technological opportunities. The rest of the economy typifies the part of production in which prospects for technological advancements are absent. The two sectors are referred to as high- and low-technology, respectively.

The high-technology sector generates technological change endogenously, and is assumed to be intensive in skilled labour. Innovation is represented by an expansion of product variety.[3] The expanding variety of products means an increase in the number of intermediates used in the production of final goods, so that the model can be interpreted as depicting process innovation (i.e. improvements in the methods of production). The sector produces the final goods χ according to the function:

$$\chi = L_{\chi}^{\beta} H_{\chi}^{1-\alpha-\beta} \int_{0}^{A} {x_j}^{\alpha} dj, \tag{2.1}$$

where L_χ is unskilled labour, H_χ skilled labour, and where $\int_0^A {x_j}^{\alpha} dj$ corresponds to an index of intermediate inputs. The intermediate inputs are capital goods, which are sold by R&D firms (i.e. firms whose purpose is to develop the blueprints for new varieties of capital goods). By extending the variety of intermediate inputs, final-good producers become more efficient, since the marginal product of each individual input is decreasing (assuming $\alpha < 1$) (see Barro and Sala-i-Martin, 2004, ch.6).

Clearly, the setup of this model is similar to the one proposed by Romer (1990*b*,*a*), with the exception that χ represents one of two sectors in the aggregate economy. In the Romer

[3]Other types of innovation could have been considered, such as quality-ladder models. However, Grossman and Helpman (1991) have shown how each type of innovation can lead to similar implications. The focus on expansion in the variety of products is therefore for simplicity of presentation.

model, a research sector produces new designs with H, skilled labour, as the sole input. In the lines that follow, I will instead represent R&D outlays as a constant fraction of final goods output (which leads to a setup similar to the Rivera-Batiz and Romer (1991) "lab-equipment" model). That is, the production of new varieties of intermediate goods has the same technology as the one introduced in (2.1). Notice that since the high-technology sector is intensive in skilled labour, it follows that research activities, being expressed in terms of the output of the whole sector, are themselves intensive in skilled labour. This is a desirable property to keep the model realistic, in the sense that producing new designs requires specialized skills that, by definition, skilled labour possesses. Considering R&D expenditures in terms of the output χ also implies that some physical capital and unskilled labour are used in the research lab (such as computers, machines, and support staff).

Let $\dot{R}$ denote R&D expenditures, conceptually defined as the fraction of resources devoted to R&D within the high-technology sector. Then

$$\dot{R} = s_R \chi, \tag{2.2}$$

where s_R is the (constant) fraction of output invested in R&D. In turn, the creation of new varieties of capital goods is a function of $\dot{R}$, such that:

$$\dot{A} = B\dot{R}^{\gamma}. \tag{2.3}$$

with B being a constant, and γ a productivity parameter (following the arguments in Jones, 1995).

The solutions for this type of model have been described in details several times before. For instance, Barro and Sala-i-Martin (2004, ch.6) provide a complete summary, as well as Rivera-Batiz and Romer (1991), Romer (1990*b*,*a*), and Grossman and Helpman

(1991). R&D firms sell (or rent) the capital goods at a monopoly price, which is a markup above marginal cost. Monopolistic competition ensures the existence of private research incentives (see the discussions in Dasgupta and Stiglitz, 1980; Romer, 1990*a*). The price of each intermediate x_j has been shown to correspond to $1/\alpha$ in equilibrium (or to $1/B$ in Rivera-Batiz and Romer (1991)), assuming a marginal cost equal to 1. The total quantity of physical capital used in the sector must in turn correspond to the sum of all intermediates, so that $x_j = \frac{K_\chi}{A}$. Substituting back into the production function, this yields the Cobb-Douglas function with labour-augmenting technological change:

$$\chi = (AL)_\chi^\beta (AH)_\chi^{1-\alpha-\beta} K_\chi^\alpha. \tag{2.4}$$

Since the present model considers research expenditures as a fraction of χ, the magnitude of research activities, $\dot{R}$, is therefore linked to the fate of the high-technology sector.

In contrast, the low-technology sector is assumed to be relatively intensive in *unskilled* labour. This sector produces final goods Z according to the function:

$$Z = F(A_0, L_Z, H_Z, K_Z) \tag{2.5}$$

where L_Z, H_Z, and K_Z respectively refer to the quantity of unskilled labour, the quantity of skilled labour, and the stocks of physical capital used in the sector Z. Here, the technology level is held constant at an arbitrary value A_0, exogenously determined. Extensions to this model could permit the low-technology sector to experience some technological progress, but at a slower rate than the high-technology sector (for instance, one may consider that after some period of time, the new capital goods developed in the high-technology sector become available to the low-technology sector). For simplicity, I assume an absence of technological advancement (or, put another way, technological change is purely exogenous as in neoclassical theory).[4] Thus, K_Z is the sole variety of capital good. The model implies that the aggregate endowments correspond to:

$$a_{L\chi}\chi + a_{LZ}Z = L_\chi + L_Z = L \tag{2.6}$$

$$a_{H\chi}\chi + a_{HZ}Z = H_\chi + H_Z = H \tag{2.7}$$

$$a_{K\chi}\chi + a_{KZ}Z = K_\chi + K_Z = K \tag{2.8}$$

where a_{ij} are the input coefficients, and L, H, and K the aggregate factor supplies.

A point emphasized by Grossman and Helpman (1991) is the need to distinguish the impact of a disproportionate change in the supply of one factor from equiproportional changes in all factors. First, if all factors increase proportionally, the model implies that the *intensity* of R&D remains unchanged. That is, the shares of industries expressed as a ratio of total output are expected to remain unaltered. In that case, however, the absolute level of R&D expenditures is increasing along with the size of the whole economy. I refer to this impact as a *scaling effect*. Second, when a factor increases disproportionally, at least in some circumstances, the Rybczynski (1955) theorem implies that the sector using that factor most intensively should expand, and the other sector contract. In other words, changes in factor intensities are expected to alter the intensity of R&D (the ratio of R&D outlays to aggregate output), because such changes affect unequally the size of the χ sector and that of the Z sector. I refer to this second impact as a *relative endowment effect*, or Rybczynski effect. Given the intensity rankings stressed above, the initial expectation is that increases in the relative endowment of L would contract private R&D, whereas increases in the relative endowment of H would expand private R&D.

Applying the Rybczynski theorem to this model implies several cautions. First, since

[4] In fact, similar implications can be derived from models that do not make such a distinction between low- and high-technology industries. See for instance Romer (1990*b*).

$\dot{R}$ is by assumption proportional to χ, this amounts to a three-factor, two-good model. In general, previous studies have shown that the Rybczynski theorem may hold in this case, although with some caveats. The theorem has been transposed to the three-factor, two-good case by Chang (1979), Jones and Easton (1983), and Suzuki (1985). Suzuki (1985) shows that a relative increase in the endowment of a factor leads unambiguously to the expansion of the sector using this factor most intensively. Yet the impact on the second sector may be ambiguous. The ambiguity is related to the degree of substitutability between factors. For instance, if unskilled workers could easily substitute for engineers in the R&D sector, then the actual costs of research may not have increased following an augmentation in the intensity of unskilled labour (although in this example, such a substitution seems to a large extent implausible). Studies considering the possibility that increases in L negatively affect private R&D (e.g. Romer, 1990*b*; Grossman and Helpman, 1991, ch.5) agree on the idea that this effect is conditional on low substitutability. When addressing the hypothesis of Habakkuk (1962), who stressed that labour scarcity has historically fostered technical change in the U.S., Acemoglu (2002) also concludes that the result holds when there is a limited degree of factor substitution.[5]

Second, the sector χ described above implies overall increasing returns to scale (an assumption that could be relaxed), whereas the sector Z could have either decreasing or constant returns to scale. The Rybczynski theorem with variable returns to scale has also been shown to hold (Jones, 1968; Panagariya, 1980), yet not without implications regarding the expected magnitude of the effects. Sorting out whether the theoretical expectations hold given factor substitution and different levels of returns to scale is a matter probably best addressed empirically, which is the goal of the next section.

[5]Note that Acemoglu (2002) considers the possibility of intentionally directed technological change, in the sense that new technologies could be designed to augment the productivity of a specific factor. This issue is not addressed here.

A last difficulty is the distinction between scaling effects and relative endowment effects. To isolate each of them, consider the following identity. R&D expenditures can be decomposed by multiplying the ratio of R&D outlays to aggregate output, by output (labelled Y):

$$\dot{R} = \frac{s_R \chi}{Y} Y = \frac{\dot{R}}{Y} Y. \tag{2.9}$$

The right-hand term $\frac{\dot{R}}{Y}$ represents R&D intensity, and this ratio is expected to evolve according to the growth in relative factor supplies, since it measures to which extent the research sector (or high-technology sector) has grown at a different rate than the traditional sector. The additional term Y captures the scaling effect, in the sense that, for a given level of R&D intensity, the absolute level of $\dot{R}$ increases with the size of the economy. To isolate the total impact on $\dot{R}$, one may add the marginal effect of a factor on $\frac{\dot{R}}{Y}$ (relative endowment effect) to its marginal effect on output (scaling effect). Based on the model introduced above, for unskilled labour, the relative endowment effect is expected to be negative, and the scaling effect positive. For skilled labour, both effects are expected to be positive. Empirical data can then be used to test those expectations. The disaggregation into two components should prove useful to understand how the influence of factor supplies on technological change actually operates.

2.2 Empirical Analysis

This section introduces an empirical model that makes possible the distinction between scaling effects and relative endowment effects. In the following lines, I first discuss the baseline econometric specification, before presenting the data. Second, I address the issues of stationarity and cointegration. The main results are then discussed, before conducting exogeneity tests, which are used to assess the validity of statistical inference.

As a first step toward the estimation of the impact of factor supplies on business R&D, I consider the first right-hand side component of the identity discussed in (2.9): R&D intensity. The specification used to estimate relative endowment effects (or "Rybczynski effects") is akin to that used by Harrigan (1995, 1997), for instance, when measuring the impact of factor supplies on sectoral output and trade. Consider the following model:

$$\frac{\dot{R}}{Y} = C\left(\frac{L}{K}\right)^{\theta_L}\left(\frac{H}{K}\right)^{\theta_H},$$
$$\ln\frac{\dot{R}}{Y} = \ln C + \theta_L \ln\frac{L}{K} + \theta_H \ln\frac{H}{K}, \tag{2.10}$$

where the main variables are defined as before, C is a constant, and where θ_L, θ_H, and $-(\theta_L + \theta_H)$ measure the elasticities of R&D intensity with respect to unskilled labour, skilled labour, and capital. Since one factor is used as the denominator, by construction the three elasticities sum to zero. The reason why those parameters sum to zero should be straightforward. By imposing the restriction that proportional increases in the three factors leave the intensity of R&D unchanged, the model estimates only the effect of a disproportionate change in factor supplies, isolating the net relative endowment effects. Put another way, since output (Y) appears as the denominator on the left-hand side, θ_L measures the impact of a change in L on R&D expenditures after filtering out the effect of a change in the size of the economy, hence yielding the Rybczynski effect. Note that any factor could have been used as the denominator to construct the right-hand side ratios: in all cases, the estimates for all three factors are exactly the same, by construction.

As a next step, consider this second model:

$$\frac{\dot{R}}{K} = D\left(\frac{L}{K}\right)^{\psi_L}\left(\frac{H}{K}\right)^{\psi_H},$$
$$\ln\frac{\dot{R}}{K} = \ln D + \psi_L \ln\frac{L}{K} + \psi_H \ln\frac{H}{K}. \tag{2.11}$$

This time, one of the factors is the common denominator to all variables (again, D is some constant, which will later be treated as country-specific intercepts). ψ_L is the elasticity of *total* R&D expenditures with respect to L, ψ_H the elasticity with respect to H, and $-(\psi_L + \psi_H) + 1$ the elasticity with respect to K. This model implies the assumption that scaling effects (the effect of proportional changes in all factors) sum to one, which means an aggregate production function exhibiting constant returns to scale in those three factors. In sum, this second model estimates the net elasticity of total R&D expenditures, including both scaling effects and relative endowment effects.

Although an aggregate production function is not estimated per se, a property of this "two-step" approach is that the estimated productivity parameters of the production function are actually contained in the two sets of estimates. The difference $\psi_L - \theta_L$ (the total effect of the factor L minus its relative endowment effect), for instance, yields the scaling effect of L on R&D outlays. This scaling effect, due to the construction of the model, corresponds to the estimated elasticity of total output with respect to unskilled labour. I do not impose any further restriction on the values of the parameters (for instance, by imposing that scaling effects correspond to factor shares as measured by some series from an external source). Therefore, the method used here avoids the need to specify some arbitrary type of aggregate production function.

To implement the empirical models, I consider panel data on 21 OECD countries, over a time-period ranging between 1971 and 2003.[6] The selection of countries is primarily determined by the availability of a key variable: business R&D expenditures ($\dot{R}$). This variable is derived from the Coe, Helpman, and Hoffmaister (2009) data set, which covers 24 countries. From those 24 countries, three have been excluded here. First, some of the other required series for Iceland and Israel are missing. Second, some of the main variables for Germany suffer from inconsistencies due to German reunification (since population data prior to reunification refer to West Germany, whereas those after reunification to Germany as a whole). Thus, Iceland, Israel and Germany are absent, which leaves 21 countries.

The variables used to estimate (2.10) and (2.11) are the following. $\dot{R}$ corresponds to annual business enterprise R&D expenditures in constant 2000 prices, and in US dollars (using the 2000 purchasing power parity (PPP) exchange rates).[7] K is a measure of physical capital stocks. It is created using the perpetual inventory method, based on the fixed capital formation series from the OECD Stats database (OECD, 2011*b*). Output Y is measured as total gross domestic product (expenditures approach), again from the OECD Stats database. All those variables are expressed in constant 2000 prices, and in PPP-adjusted US dollars. Next, the inclusion of L and H proceeds as follows. The OECD working-age population series (i.e. population aged between 15 and 64) have been extracted, and skilled labour H is obtained by multiplying working-age population by the ratio of working-age population with a completed tertiary education degree. Since a number of issues have been raised over the years regarding the measurement of educational attainment, I consider two distinct sources: the Barro and Lee (2010) data set, version 1.2,

[6]Those countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

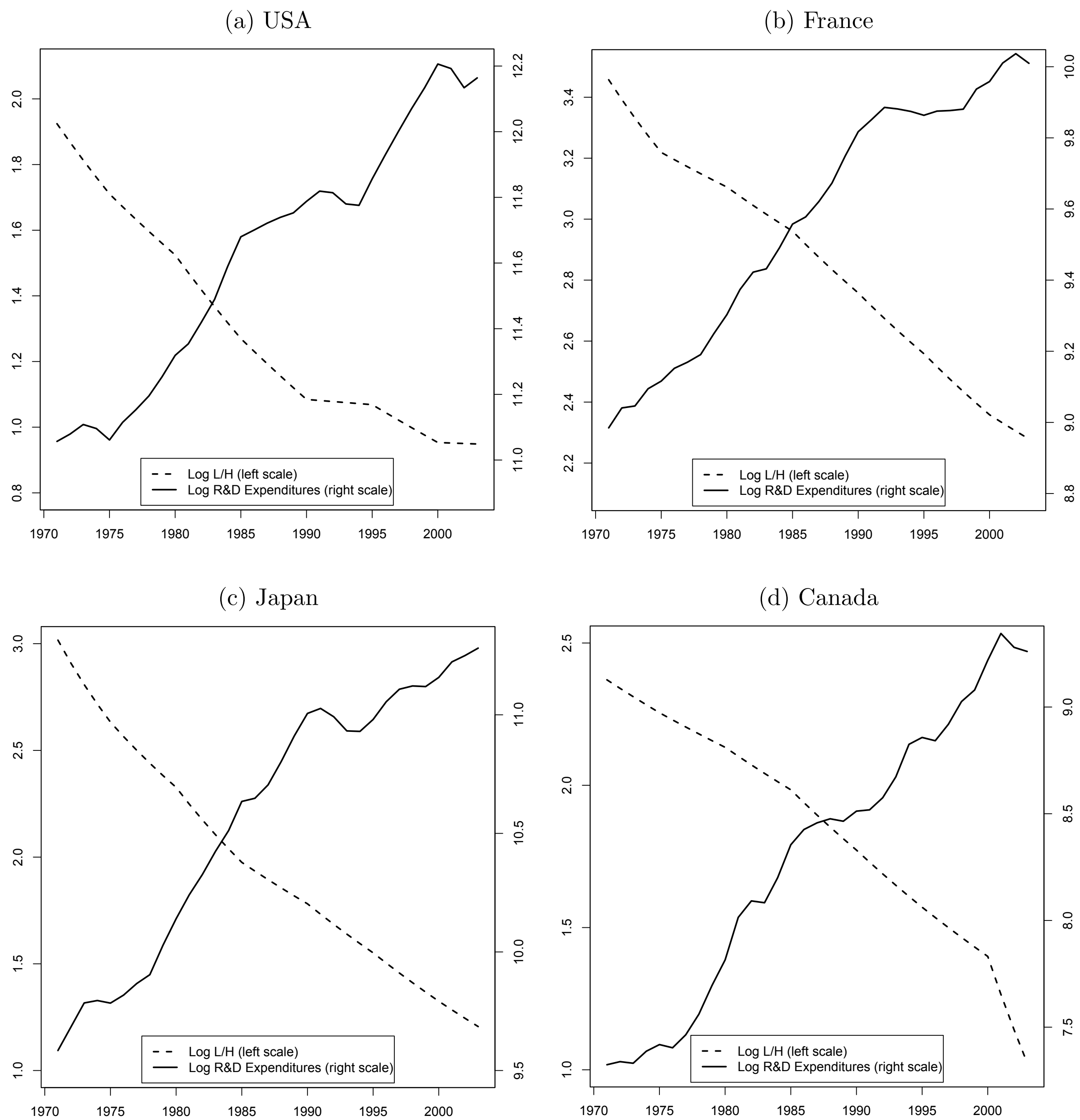
[7]This variable relies upon the business R&D capital stocks series from the Coe, Helpman, and Hoffmaister (2009) data set, converted into annual expenditures. The primary data source is OECD's ANBERD database. Further details regarding the definition and measurement of business R&D expenditures in OECD countries can be found in the Frascati Manual (OECD, 2002).

and the International Institute for Applied Systems Analysis (World Population Program) data set (Lutz et al., 2007). Both these sources provide detailed data on educational attainment by age groups, allowing to retrieve the share of working-age population with tertiary education. Unskilled labour L is measured as the stocks of working-age population without a completed tertiary education degree. Finally, I introduce an additional variable measuring the appropriability of R&D returns (which is a necessary condition for the presence of private incentives to invest in R&D), using the patent protection index devised by Park and Lippoldt (2005), and provided in the Coe, Helpman, and Hoffmaister (2009) data set. This variable measures the extent of legal protection of intellectual property rights. The appendix presents additional details regarding the data.

Before turning to a detailed estimation, Figure 2.1 shows the actual trends in R&D expenditures in four OECD countries (USA, France, Japan, and Canada). Those series are stacked against the ratio of L to H, a measure of unskilled labour intensity (with variables based on the Barro-Lee data set). The scale on the right y-axis measures the levels of R&D expenditures (in millions, converted to natural logs), whereas the scale of the left y-axis measures the levels of the log $\frac{L}{H}$ ratios. The four panels illustrate one of the main points of this paper: the increase in the scope of R&D activities over time coincides with a fall in the relative intensity of unskilled labour (put the other way, with an increase in the relative intensity of skilled labour). A negative relationship can also be observed between the rate of growth of working-age population (without the distinction between skill levels) and total R&D expenditures. For instance, considering the 21 countries over the 1971-2003 period, the demeaned correlation coefficient between R&D expenditures and population growth is -0.42 (significant at the $p < 0.001$ level).

However, to confirm the existence of a genuine equilibrium relationship between factor supplies and R&D outlays, a number of issues must be addressed. First, I test each

Figure 2.1: Unskilled Labour Intensity and R&D Expenditures in 4 Countries (1971-2003)



variable of the main models for trend stationarity, using panel unit root tests. This step is mandatory, to avoid spurious regression estimates under the form of biased t statistics. As emphasized by Hurlin and Mignon (2005), unit root testing has become the starting point of many empirical works involving a temporal dimension, and panel data help to improve the power of unit root tests when the number of time units is limited (see also Baltagi and Kao, 2000). Depending on the presence of unit roots, panel cointegration tests would be required to confirm whether the stochastic trends in the variables are related. The choice of a consistent estimator will depend on the results of those tests. Second, fixed effects (i.e. country-specific intercepts to estimate the "within" dimension) represent a powerful econometric tool to account for the role of country-specific unobserved factors that may have an influence on R&D activities (e.g. the structure of competition). Finally, I examine the exogeneity of factor supply variables using an error-correction representation of the models, later in this section.

2.2.1 Unit Roots and Cointegration

Table 2.1 reports the results of panel unit roots tests performed on each of the variables of the two models. I use the superscript BL when referring to variables constructed using the Barro-Lee data set on educational attainment, while the superscript LU indicates the use of the Lutz et al. data set. The variable PP is the above-mentioned patent protection index. The table shows the results of the Levin-Lin-Chu (Levin, Lin, and Chu, 2002) and the Im-Pesaran-Shin (Im, Pesaran, and Shin, 2003) panel unit root tests. Both have the null hypothesis of a unit root in all panels, but the latter takes into account the potential heterogeneity of autoregressive parameters under the alternative hypothesis (Hurlin and Mignon, 2005, 266). Both these tests are performed with two lags, against the alternative of trend stationarity (an obvious choice based on the visual inspection of the series in Figure

1). As Table 2.1 shows, the tests suggest that all variables contain unit roots. Increasing lag length (for instance following the Newey and West (1994) rule of $4(T/100)^{2/9}$, where T is the number of time periods (in this case 32, suggesting 3 lags)) tends to reinforce the same conclusion. I therefore treat each of the variables as integrated of order one ($I(1)$) in the lines that follow.

Table 2.1: Panel Unit Root Tests

Variable	Levin-Lin-Chu t^*_δ	Im-Pesaran-Shin W_{tbar}
$\ln \dot{R}/Y$	0.097	–0.627
$\ln \dot{R}/K$	0.023	–1.132
$\ln L/K^{BL}$	–0.012	2.390
$\ln H/K^{BL}$	0.715	3.388
$\ln L/K^{LU}$	–0.368	2.658
$\ln H/K^{LU}$	2.348	7.009
$\ln PP$	–0.140	–0.473

The Levin-Lin-Chu panel unit root test statistic t^*_δ is computed with two lags, using a Bartlett kernel with Newey-West automatic bandwidth selection, against the alternative of trend-stationarity (including individual intercepts and trends). The Im-Pesaran-Chin W_{tbar} is also computed with two lags against the alternative of trend stationarity. All statistics are non-significant, indicating the presence of unit roots in all panels.
$^{***}: p < 0.001$; $^{**}: p < 0.01$; $^{*}: p < 0.05$.

The next step consists of testing for the existence of a cointegrating relationship in the two regression models introduced in (2.10) and (2.11), augmented to include the measure of appropriability as a control variable. Evidence of cointegration would entail a relationship between the stochastic trends of the variables under consideration, and the existence of a linear combination of those variables that is stationary. Given the format of the data, I make use of residuals-based panel cointegration tests, namely Pedroni's panel-ADF and group-ADF statistics (introduced as the parametric panel-t and group-t statistics in Pedroni (1999)), named after their similitude to the augmented Dickey-Fuller statistics. Wagner and Hlouskova (2009) compared the performance of several existing panel cointegration tests (including systems-based tests), and concluded that Pedroni's panel-ADF and group-ADF outperform the other tests. Moreover, they show that Pedroni's statistics are the most robust to cross-sectional correlation. The "group" version of the test corresponds to a group-mean aggregation of cointegration tests performed on individual panels, whereas the weighted "panel" statistics are pooled along the within-dimension (Pedroni, 1999). The two tests are performed for each of the two main models, but also for alternative specifications (i.e. after modifying the source of education data). All tests include individual intercepts and trends. They are computed with automatic lag length selection (based on the Schwarz information criterion) and bandwidth selection (based on Newey and West), the latter being used for the computation of long-run variances.

Focusing on the panel-t statistic, it can be observed from Table 2.2 that the null of no cointegration is clearly rejected in all cases, at the $p < 0.001$ level. Moreover, the group-t statistics are also significant at the $p < 0.001$ level. Overall, those results provide strong supporting evidence to the idea that there is a long-run equilibrium relationship between factor supplies and R&D outlays.

Table 2.2: Panel Cointegration Tests

Response	Regressors	Panel-t (ADF)	Group-t (ADF)
$\ln \dot{R}/Y$	$\ln L/K^{BL}, \ln H/K^{BL}, \ln PP$	–3.698***	–3.918***
$\ln \dot{R}/K$	$\ln L/K^{BL}, \ln H/K^{BL}, \ln PP$	–3.649***	–4.698***
$\ln \dot{R}/Y$	$\ln L/K^{LU}, \ln H/K^{LU}, \ln PP$	–3.300***	–3.386***
$\ln \dot{R}/K$	$\ln L/K^{LU}, \ln H/K^{LU}, \ln PP$	–3.909***	–4.554***

The table reports Pedroni's parametric weighted panel-t and group-t cointegration test statistics of the null hypothesis of no cointegration. All tests are performed with automatic lag length selection based on the Schwarz information criterion (with maximum lag length of 6, based on the size of the sample), and using a Bartlett kernel for the estimation of long-run variances (with automatic bandwidth selection based on Newey-West). The tests are also performed while including individual intercepts and trends.
$^{***}: p < 0.001$; $^{**}: p < 0.01$; $^{*}: p < 0.05$.

2.2.2 Main Empirical Findings

Given the verdict of cointegration, I implement a dynamic OLS (DOLS) version of the main models. Early descriptions as well as discussions on the efficiency of the DOLS estimator can be found in Saikkonen (1991) and Stock and Watson (1993). Kao and Chiang (2000) discuss the implementation with panel data (see also Breitung and Pesaran, 2008). The DOLS model implies the inclusion of leads and lags of the difference operators for each of the $I(1)$ explanatory variables. For example, the R&D intensity equation becomes:

$$\ln \frac{\dot{R}}{Y}_{i,t} = \delta_i + \Phi_t + \theta_L \ln \frac{L}{K}^{BL}_{i,t} + \theta_H \ln \frac{H}{K}^{BL}_{i,t} + \theta_P \ln PP_{i,t} + \sum_{j=-1}^{1} \lambda_{L/K,j} \Delta \ln \frac{L}{K}^{BL}_{i,t+j} + \sum_{j=-1}^{1} \lambda_{H/K,j} \Delta \ln \frac{H}{K}^{BL}_{i,t+j} + \sum_{j=-1}^{1} \lambda_{PP,j} \Delta \ln PP_{i,t+j} + \varepsilon_{i,t}, \tag{2.12}$$

where the variables are defined as before. The country-specific and time intercepts (δ_i, Φ_t) imply that the model is estimated along the within dimension, using two-way fixed effects—a model without the time dummies is also investigated below. (2.12) presents only one variant of the two models discussed above, but the other one is constructed in a similar manner, modifying only the response variable. The DOLS estimator has many interesting properties: it includes leads of the difference operators limiting concerns about endogeneity, and it is appropriate in the presence of cointegrated series (see the references above for details). To palliate for serial auto-correlation and heteroskedasticity, all the statistics reported below are computed using HAC (heteroskedasticity and auto-correlation consistent) standard errors (Andrews, 1991), with degrees-of-freedom adjustment for panel data.

Table 2.3 shows the estimation results with labour supply variables created using the

Barro-Lee data set as the source of educational data. I focus mainly on this variant of the models for simplicity, although the results using the alternative data source are also discussed below. The first two columns of Table 2.3 report the DOLS implementation of the models, without the inclusion of the measure of intellectual property rights.[8] The next two columns show the results after including this control variable, but without time dummies. The last two columns replicate the models while including time dummies as regressors (two-way fixed effects), to account for unobserved temporal shocks.

Table 2.3: The Impact of Factor Supplies on R&D Expenditures (21 OECD Countries, 1971-2003)

	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Variable	$\ln \dot{R}/Y$	$\ln \dot{R}/K$	$\ln \dot{R}/Y$	$\ln \dot{R}/K$	$\ln \dot{R}/Y$	$\ln \dot{R}/K$
$\ln L/K^{BL} (\ln L)$	–1.133***	–0.946***	–0.625***	–0.348**	–0.776***	–0.489**
	(0.082)	(0.075)	(0.140)	(0.132)	(0.168)	(0.161)
$\ln H/K^{BL} (\ln H)$	0.448***	0.665***	0.122	0.296**	0.207	0.384***
	(0.085)	(0.081)	(0.095)	(0.092)	(0.113)	(0.109)
$(\ln K)$	0.685***	1.281***	0.502**	1.051***	0.569***	1.105***
	(0.142)	(0.129)	(0.166)	(0.155)	(0.157)	(0.150)
$\ln PP$			1.047***	1.215***	1.342***	1.529***
			(0.160)	(0.157)	(0.148)	(0.150)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	No	No	No	No	Yes	Yes
Adj.–R^2	0.93	0.94	0.94	0.95	0.95	0.96
N	651	651	651	651	651	651

The table shows estimates of DOLS models including one lead and one lag of the differences of the right-hand side $I(1)$ variables, and computed with HAC standard errors (with a Bartlett kernel and a fixed bandwidth truncated after two lags), the latter being reported in parentheses. The response variables for Model 1 and Model 2 are indicated in the column headers. All models are estimated along the within dimension (i.e. including country-specific intercepts). See text for the interpretation of estimates.
$^{***}: p < 0.001$; $^{**}: p < 0.01$; $^{*}: p < 0.05$.

The columns labelled "Model 1" report the elasticity of R&D intensity with respect to relative factor supplies (i.e. the relative endowment effects), as explained in the intro-

[8]Note that cointegration tests similar to those reported above have been conducted for models without the $\ln PP$ control variable, and the verdict of cointegration holds in all cases as well.

duction of this section. "Model 2" refers to the findings for the model estimating total effects (i.e. relative endowment effects plus scaling effects). Estimates can be interpreted straightforwardly. For instance, in Model 1, the estimate for the variable $\ln \frac{L}{K}^{BL}$, labelled θ_L above, indicates the percent change in R&D intensity for a 1% increase in the value of $\frac{L}{K}$, holding constant the ratio $\frac{H}{K}$ (and the level of appropriability PP). Therefore, θ_L also indicates the impact of a 1% increase in the absolute level of L on R&D intensity, holding constant the other factors.

Consider Model 1 in the last section of Table 2.3, which includes time dummies. The estimates indicate that R&D intensity is negatively related to the supply of unskilled labour: a 1% increase in the supply of unskilled labour leads to an estimated –0.78% fall in the intensity of R&D, all else equals. This finding is consistent with the theoretical model, which stressed the idea that a relative increase in unskilled labour leads to the expansion of more traditional activities, and to the contraction of the research sector. This estimate is statistically significant at the $p < 0.001$ level. Besides, physical capital (rather than skilled labour) appears as the factor used most intensively in the research sector, as revealed by the unambiguously positive estimate. This finding lends initial credence to models of endogenous technological change in which capital is the main input in the research sector (e.g. Howitt and Aghion, 1998). Skilled labour appears as the "middle-factor", with a positive elasticity of 0.2, although short of being statistically distinguishable from zero. Finally, the patent protection index has an unsurprising positive effect on the intensity of R&D, suggesting that intellectual property rights stimulate private research.

When addressing the absolute levels of R&D expenditures, however, scaling effects must also be taken into consideration. Thus, the impact of an increase in L on R&D intensity may well be negative, but on the other hand, L contributes to making the economy larger. In other words, from the identity $\dot{R} = \frac{\dot{R}}{Y}Y$, the effect of resource composition on the component $\frac{\dot{R}}{Y}$ has been estimated in the previous step. Adding the contribution of each factor to the growth of output yields the effect of those factors on absolute levels of R&D.

Model 2 of Table 2.3 reports the elasticities for total R&D expenditures, including scaling effects. For instance, and still focusing on the last columns of Table 2.3, the elasticity of R&D with respect to L becomes –0.49. This implies that L has a scaling effect of ≈ 0.3 (–0.49 – (–0.78)). A 1% increase in unskilled labour is expected to depress R&D intensity by –0.78%, but to increase total output by 0.3%, hence scaling up the total amount of R&D expenditures by 0.3%. Overall, then, a 1% increase in L induces a change of about –0.5% in total R&D expenditures, all else equals. Notice that the approach used here avoids the flawed conclusions that may result when failing to disentangle the influence of factor supplies. The bivariate correlation between L and total R&D outlays is positive, but this correlation disguises the fact that the temporal rise in L occurs along with the increase in other factors (in fact, as discussed below, those other factors of production, H and K, happen to have increased much more rapidly than L have). By isolating the contribution of each factor, and with the distinction between relative endowment and scaling effects, the results presented here unveil a more detailed account of the impact of factors of production. Continuing with the results of Table 2.3, it can be seen that skilled labour has an overall positive and significant impact on total R&D outlays (with an elasticity of the order of 0.38). As for physical capital, it again turns out as the extreme factor in the R&D process. Notice that the appropriability variable is still included among the regressors in the second model, for consistency with the first model. Dropping this variable implies that each of the elasticities discussed so far becomes magnified, as can be observed in the first two columns of Table 2.3. Finally, when omitting time dummies, as in the middle columns, the substantive findings remain quite similar to those just discussed, although estimates are slightly smaller in absolute magnitude.

More generally, those findings are consistent with the following fact. As the countries under study experienced episodes of major technological improvements over the last decades, the stocks of physical capital and skilled labour have actually grown much more rapidly than unskilled labour. The compound annualized growth rate of capital, averaged across countries, has been 3.1% for the time-period 1971-2004. In contrast, the compound annual growth of unskilled labour has been 0.6% (five times lower than that of capital), while the annual growth of skilled labour has been 4.3%. Therefore, the findings suggest that a major source of technological change in OECD countries has been the divergence between those growth rates: the last decades are marked by the relatively slow rate of growth of unskilled labour, combined with an accelerated growth of capital and skilled labour. The above estimates indicate that precisely in such circumstances, R&D activities flourish, with an increasing portion of economic resources being devoted to research.

Some of the previous results are slightly altered when modifying the source of the educational data used to construct L and H. Table 2.4 reports the full set of elasticities, computed with two-way fixed effects. The models using the Lutz et al. data are estimated in a way similar to the ones that have been discussed in details above. When the factor variables are built using the Lutz et al. data, the factor endowment effect of skilled labour turns out to be larger. The new estimate is 0.7 (compared to 0.2), and skilled labour now appears as the extreme factor, whereas capital appears as the middle factor (as was initially assumed in the theoretical section). The scaling effects are rather similar, however, and the signs of the estimates remain consistent.

Table 2.4: Elasticities of Business R&D Expenditures with Respect to Factor Endowments

Education Data	Factor	Rybczynski Effect	Scaling Effect	Total Elasticity
Barro-Lee	Unskilled Labour	–0.78	+0.29	–0.49
	Skilled Labour	+0.21†	+0.18	+0.38
	Physical Capital	+0.57	+0.54	+1.10
Lutz et al.	Unskilled Labour	–0.95	+0.38	–0.57
	Skilled Labour	+0.72	+0.10	+0.81
	Physical Capital	+0.23†	+0.52	+0.75

Summary of estimates from DOLS models similar to those reported in the last two columns of section Table 3 (including the measure of appropriability as a control, individual intercepts and time dummies), but with variations in the source of educational data. Scaling effects are implied (see text). All estimates are statistically significant at the $p < 0.05$ level (using HAC standard errors), expect those flagged with the † sign.

2.2.3 Exogeneity

An issue of concern to some may be the exogeneity of factor supplies. Although the reliance on a fixed effects estimator strongly reduces the risk of endogeneity bias under the form to omitted variables (by controlling for unit-level unobserved factors, and common temporal factors in the case of two-way fixed effects), and despite the robustness of the DOLS estimator to endogeneity with the inclusion of lead differences, one may shed theoretical doubt on the exogeneity of factor supplies. For instance, R&D, by inducing technological improvements and thus increases in per capita wealth, can also affect birth and schooling decisions. To address those concerns, I develop an error-correction implementation of the main models introduced above, in order to test both R&D and factor supply variables for weak exogeneity (see Engle, Hendry, and Richard, 1983, for an extended discussion on concepts of exogeneity).

Consider the following error-correction representation, leaving open the possibility that each variable is endogenous. For simplicity, let me focus again on the first variant of the models introduced above, where educational data are based on the Barro and Lee

(2010) data set. For consistency with the previous subsection, I consider the measure of appropriability as part of the system. Also, let the two-way fixed effects represent the context within which the cointegration relationship takes place. The evidence of cointegration reported above implies that the residuals of the long-run equations,

$$\varepsilon_{1,i,t} = \ln \dot{R}/Y_{i,t} - \delta_{1,i} - \Phi_{1,t} - \theta_L \ln L/K^{BL}_{i,t} - \theta_H \ln H/K^{BL}_{i,t} - \theta_P \ln PP \tag{2.13}$$

$$\varepsilon_{2,i,t} = \ln \dot{R}/K_{i,t} - \delta_{2,i} - \Phi_{2,t} - \psi_L \ln L/K^{BL}_{i,t} - \psi_H \ln H/K^{BL}_{i,t} - \psi_P \ln PP \tag{2.14}$$

are stationary I(0) processes.

The error-correction representation for the first model (with R&D intensity, yielding the Rybczynski effects) is then given by:

$$\begin{aligned}
\Delta \ln \frac{\dot{R}}{Y}_{i,t} &= \pi_{10}\hat{\varepsilon}_{1,i,t-1} + \sum \pi_{11}(j)\Delta \ln \frac{\dot{R}}{Y}_{i,t-j} + \sum \pi_{12}(j)\Delta \ln \frac{L}{K}_{i,t-j} \\
&\quad + \sum \pi_{13}(j)\Delta \ln \frac{H}{K}_{i,t-j} + \sum \pi_{14}(j)\Delta \ln PP_{i,t-j} + \upsilon_{1,i,t}, && (2.15) \\
\Delta \ln \frac{L}{K}_{i,t} &= \pi_{20}\hat{\varepsilon}_{1,i,t-1} + \sum \pi_{21}(j)\Delta \ln \frac{\dot{R}}{Y}_{i,t-j} + \sum \pi_{22}(j)\Delta \ln \frac{L}{K}_{i,t-j} \\
&\quad + \sum \pi_{23}(j)\Delta \ln \frac{H}{K}_{i,t-j} + \sum \pi_{24}(j)\Delta \ln PP_{i,t-j} + \upsilon_{2,i,t}, && (2.16) \\
\Delta \ln \frac{H}{K}_{i,t} &= \pi_{30}\hat{\varepsilon}_{1,i,t-1} + \sum \pi_{31}(j)\Delta \ln \frac{\dot{R}}{Y}_{i,t-j} + \sum \pi_{32}(j)\Delta \ln \frac{L}{K}_{i,t-j} \\
&\quad + \sum \pi_{33}(j)\Delta \ln \frac{H}{K}_{i,t-j} + \sum \pi_{34}(j)\Delta \ln PP_{i,t-j} + \upsilon_{3,i,t}, && (2.17)
\end{aligned}$$

where the last case (with $\Delta \ln PP$ as the response variable) is omitted for simplicity. Since the differenced variables are I(0) by construction, all the variables used in those equations are stationary. The t-statistics for π_{10}, π_{20}, and π_{30} (the estimates for the lagged error-correction terms) are of interest. A statistically significant value for π_{10} would confirm that there is a significant long-run effect of innovations in factor supplies and appropriability on R&D. Most importantly, non-significant statistics for π_{20} and π_{30} would imply that the response variables (in those cases, factor supplies) are *weakly exogenous* (Engle, Hendry, and Richard, 1983; Enders, 2010, ch.6), hence confirming the validity of the statistical inferences stressed in the previous subsection. The error-correction equations for the alternative specifications are constructed in a similar way.

Table 2.5: ECM-Based Weak Exogeneity Tests

		Education Data:	
		Barro-Lee	Lutz et al.
Model Type	Response	$\hat{\varepsilon}_{t-1}$	$\hat{\varepsilon}_{t-1}$
Model 1	$\Delta \ln \frac{\dot{R}}{Y}$	–0.0715**	–0.0777**
		(0.0208)	(0.0219)
	$\Delta \ln \frac{L}{K}$	–0.0017	–0.0013
		(0.0022)	(0.0020)
	$\Delta \ln \frac{H}{K}$	0.0021	–0.0016
		(0.0025)	(0.0027)
Model 2	$\Delta \ln \frac{\dot{R}}{K}$	–0.0814**	–0.0894**
		(0.0241)	(0.0242)
	$\Delta \ln \frac{L}{K}$	–0.0021	–0.0017
		(0.0023)	(0.0021)
	$\Delta \ln \frac{H}{K}$	0.0019	–0.0018
		(0.0026)	(0.0029)

The table shows estimates of the lagged error-correction terms for the ECM representation of the main models (including appropriability ($\ln PP$) as a control variable, which is not reported for ease of presentation). A significant estimate indicates that the response variable is endogenous, and that innovations in the regressors have a significant long-run influence on the response variable. Non-significant estimates indicate that the response variable is weakly exogenous. The differenced equations are estimated with OLS, including two lags of each regressor, and using heteroskedasticity robust clustered standard errors (reported in parentheses).
*** : $p < 0.001$; ** : $p < 0.01$; * : $p < 0.05$.

Table 2.5 reports the estimates for the error-correction terms, for each of the specifications used previously. In each case, the cointegrating regressions were first estimated, to obtain the residuals. The error-correction models are then estimated by OLS, with heteroskedasticity-robust standard errors (clustered by panel). All models are estimated with two lags of the differenced regressors. As can be observed from Table 2.5, for all of the specifications, there is solid evidence that factor supply variables are weakly exogenous, as revealed by the non-significant statistics when using factor supplies as the response variables. In contrast, R&D variables (no matter their form) consistently appear as endogenous, as was initially theorized in this paper. Overall, those results yield unambiguous support to the validity of inferences made previously, using Tables 2.3 and 2.4, concerning the relationship between factor supplies and private R&D.

2.2.4 Policy Implications

The results of the last subsections may prove useful to derive policy implications. I consider two examples in this section, by contrasting immigration policies with education policies. Immigration policies are typically used by states to determine the number of residence permits granted to foreigners. When states select foreigners according to their socio-demographic characteristics, immigration policies are by definition a controlled modification to the supplies of skilled and unskilled labour in the recipient country. The elasticities provided in Table 2.4 can help to evaluate the impact of such policies, based on the assumption that immigrants and natives of the same skill level are interchangeable. As for education policies, they may affect the composition of labour resources, by increasing the ratio of working-age population with a tertiary degree. However, a caveat must be raised regarding point predictions. The use of alternative sources for educational data has shown that parameter constancy is not fully achieved. However, the estimated signs of the elasticities and the validity of inference are robust. For illustrative purposes, and keeping in mind the caveat just mentioned, I discuss in the following lines some stylized policy implications.

An immigration policy causing a proportional increase in both unskilled labour and skilled labour would generate an aggregate impact on total R&D expenditures close to nil, whereas the effect on R&D intensity would be slightly negative. Depending on the source of educational data used, the estimated effect on total R&D outlays for a 1% increase in both L and H through immigration would range between –0.11% and +0.24%. To understand the meaning of this calculation, contrast the case of a 1% increase in skilled labour alone. This change induces an estimated increase between +0.38% and +0.81% in total R&D. By adding the growth in unskilled labour, the disproportionate increase that favours the research sector over the other economic activities is lost, reducing down the net effect that would have been obtained had skilled labour alone increased. The estimated effect of the same proportional policy on R&D intensity, on the other hand, would range between –0.6% and –0.2%. Thus, the findings of this paper imply that R&D intensity reacts acutely to changes in the supply of unskilled labour.

Policies that increase both the supplies of skilled and unskilled labour at the same rate may be quite close to what actually occurs in a typical OECD country in the recent years. For instance, according to OECD's DIOC-E database (described in Dumont, Spielvogel, and Widmaier, 2010), which contains census-based cross-sectional information on the educational attainment of the foreign-born population in recipient countries, the average share of foreign-born population with a completed tertiary degree in the countries under study is about one fourth. This value is quite close to the actual share in the native population, also around one fourth (both values are extracted from the same source). If one assumes that the mix of skilled/unskilled among new entrants is similar as well, then the typical policy tends to fall close to the example just described, where both L and H grow at the same rate. That is, holding constant other sources of change in factor supplies, the typical immigration policy would generate little effect on the total quantity of private R&D expenditures, and a slight depressing effect on the intensity of R&D.

In contrast, the impact of a policy that would stimulate an increase in the tertiary graduation rate can be assessed as follows. Consider an initial state in which a working-age population of size N is composed of $hN = H$ skilled workers, and $(1 - h)N = L$ unskilled workers, where h is the ratio of the working-age population with a completed tertiary degree. Suppose that a policy is expected to produce the counterfactual state $h'N = H'$ and $(1 - h')N = L'$. Clearly, $h' > h$ implies that $H' > H$ and $L' < L$, so that the direction of the estimated effect on business R&D is unambiguous, all else equals. For instance, let $h = 0.25$ and $h' = 0.255$. For N constant, a change from h to the counterfactual level h' corresponds to a 2% increase in H, and a 0.7% fall in L. The estimated effect on absolute levels of business R&D expenditures, based on the elasticities of Table 4, would range between +1.1% and +2%. Note that such a calculation leaves aside temporal changes in factor supplies. It also assumes that the quality of the graduates remains the same under the two scenarios. In practice, manipulating the graduation rate through education policies may not be as straightforward as expanding labour supply through immigration, since the former may require a variety of policy instruments, the efficiency of which needing to be assessed. Nonetheless, this stylized example suggests that education plays an important role in the development of the private research sector, through its effect on labour resource composition.

2.3 Conclusion

This study sought to demonstrate how changes in the supplies of unskilled and skilled labour affect the scope of business R&D activities. The model incorporates three factors of production, and builds upon the idea that high-technology industries make intensive use of skilled labour (in contrast with traditional industries, intensive in unskilled labour). R&D intensity was expected to respond negatively to disproportionate increases in the supply of unskilled labour, and conversely following relative increases in the supply of skilled labour. On the other hand, proportional increases in the supply of all three factors were expected to generate scale effects, in the sense of higher absolute levels of expenditures in R&D. Empirical data on OECD countries have been found to be consistent with those expectations.

Based on an econometric specification distinguishing scale effects from relative endowment effects, the results suggest that a soaring supply of unskilled labour dampens private R&D expenditures, even after accounting for scale effects. In fact, the positive trends in R&D expenditures observed in OECD countries can be largely explained by the growth in the intensity of capital and skilled labour, rather than population growth per se, as was argued in recent publications. Indeed, capital and skilled labour have increased over five times more rapidly than unskilled labour during the last decades, while fertility rates have been declining. Thus, the results help to clarify the role of population for technological change. More people may well mean more ideas, but those ideas must also make it to the research lab. And a fast growing population can thwart R&D efforts when it augments the intensity of unskilled labour, since productive activities adapt to resource composition. Overall, by highlighting the role of factor intensities, the argument of this paper proposes an explanation of technological change that is quite consistent with empirical reality.

The findings of this paper yield implications for policies. I have discussed two stylized examples. First, the empirical estimates were used to illustrate the impact of immigration policies on the private research sector. This impact depends on the mix of unskilled and skilled migrants entering the labour market. An example realistically close to the situation in an average OECD country was considered, showing that the effects of skilled and unskilled immigration on absolute levels of business R&D expenditures tend to offset each other. On the other hand, the undermining impact of unskilled immigration on the intensity of R&D prevails. Second, an education policy increasing the ratio of working-age population with a tertiary degree has an unambiguous estimated impact on business R&D, insofar as it induces a net increase in the supply of skilled labour relative to unskilled labour. Although a full assessment of those implications falls beyond the scope of this paper, extensions to this study could further emphasize the role played by policies in changing the composition of labour over time, hence affecting the extent of private incentives to innovate.

Appendix 2.1

Capital Stocks (K) and Output (Y). Both variables come from the OECD Stats database. Y is measured as total GDP (expenditure approach), and corresponds to the series B1_GE, in constant prices, and constant PPP-adjusted US dollars (base 2000). Gross fixed capital formation comes from the series B1_GE, P51. Capital stocks are computed using the perpetual inventory method. The depreciation rate is assumed to be 0.05, and the benchmark for 1970, for each country i, is computed as:

$$K_{i,1970} = \frac{\dot{K}_{i,1970}}{\delta + g_{K,i}},$$

where $g_{K,i} = \frac{\ln\left(\frac{\dot{K}_{i,1985}}{\dot{K}_{i,1970}}\right)}{15}$.

Unskilled Labour (L) and Skilled Labour (L) stocks. Those variables are computed as:

$$L_{i,t} = N_{WA,i,t} * (1 - h_{i,t}); H_{i,t} = N_{WA,i,t} * (h_{i,t})$$

where $N_{WA,i,t}$ is working-age population in country i at year t (from OECD, 2011b), and where $h_{i,t}$ is the share of working-age population with a completed tertiary degree. As mentioned in the text, two alternative sources for h are considered (Barro and Lee, 2010; Lutz et al., 2007). The h series have been linearly interpolated within the five-year data points provided in the initial data sets.

Chapter 3

Corporate Lobbying and Immigration Policies in Canada

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Abstract

This study examines the enduring claim that firms exert influence on immigration policies, prompting governments to open the doors to foreign labour. Although intuitively appealing, this claim has received little empirical support so far, the actual channels of influence from special interests to policy makers being usually opaque to public scrutiny. To address this problem, I rely upon the vector autoregression methodology and make use of fine-grained quarterly data on lobbying, skills-based immigration and temporary workers in Canada, between 1996 and 2011. A key result is the positive and robust response of temporary worker inflows to the intensity of corporate lobbying, even after accounting for labour market conditions. In contrast, there is no conclusive evidence that lobbyists carry weight when it comes to permanent migrants.

Do special interest groups affect the behaviour of politicians? The question lies at the heart of the idea of representativeness and has spurred a wide range of views, from the most censorious (Schattschneider, 1975) to the most optimistic (Dahl, 1961). This debate is especially relevant to understand immigration policies. Indeed, scholars have emphasized and disputed the existence of a discrepancy between the restrictive preferences of the public and the apparent openness to immigration in Western countries (Freeman, 1998, 2002; Joppke, 1998; Lahav, 2004; Statham and Geddes, 2006). The usual suspects behind expansive immigration policies are private firms, who would benefit from the depressive impact of foreign labour on wages. Even so, the channels through which interest groups allegedly contrive to secure policy concessions from elected officials remain for the most part concealed, and so far there has been little quantitative evidence supporting the view that corporate interests exert influence on immigration policy outcomes.

This paper's objective is precisely to examine the impact of corporate lobbying on the levels of immigration in Canada. To begin with, I argue that national industries are unequally affected by changes in the skill composition of labour. As a result, rather than advocating an unconditional expansion of immigration levels, the business community is more likely to agree on the desirability of policy tools allowing the selection of migrants with specific skills and backgrounds. I focus on the two most relevant instruments serving this purpose in Canada, namely, economic permanent immigration (that is, immigrants selected using a point system accounting for criteria such as educational attainment) and temporary workers (who are selected based on their intended occupation). The theoretical section emphasizes that even if special interests can exert a significant influence on policy makers motivated by re-election, the equilibrium response of governments depends on the complementarity between those two types of immigration. Using quarterly data on corporate lobbying, temporary workers and economic migrants in Canada (from 1996-Q1 to 2011-Q4), I implement a vector autoregression (VAR) model taking into account the full nature of the interrelations between those three series.

The idea that businesses play a key role in the shaping of immigration policies has been discussed several times before (see e.g. Freeman, 1995; Borjas, 2001; Tichenor, 2002; Menz, 2009). However, quantitative evidence is limited by the difficulty of measuring the process of influence. In a large-scale study including an extended set of interviews, Baumgartner et al. (2009) conclude that lobbies are in general unsuccessful at securing policy concessions — although their study does not address the issue of immigration in particular. In Nicholson-Crotty and Nicholson-Crotty (2011), the authors examine the relationship between business interests and immigration in the United States. They find an association between shares of labour-intensive industries and the openness to immigration, and they also consider corporate donations at the state level. However, they do not have a direct measure of business influence on the specific issue of immigration. Another recent quantitative study is Facchini, Mayda, and Mishra (2011), in which the authors examine the relationship between lobbying expenditures from US industries and the number of temporary work visas. The present study contributes to this literature by making use of detailed Canadian lobbying data over time and by considering both permanent and temporary immigration. The empirical findings show that an increase in the intensity of corporate lobbying on the issue of immigration has a positive impact on the levels of temporary workers admitted to Canada. This relationship appears robust and is supported by causality tests. As for the levels of permanent immigrants, they appear less responsive to lobbying pressures. Those findings lead to new insights regarding the politics of immigration in Canada, suggesting that temporary immigration represents a coveted source of foreign labour for national industries.

In the following section, I introduce the theoretical background. I first proceed with an argument about the preferences of corporations over immigration before looking at the influence of lobbying in the policy-making process. Next, I introduce the data and address important substantive issues. Then, an empirical section proceeds with a multiple time series analysis, and discusses the results. A final section concludes.

3.1 Theoretical Framework

A persistent claim in the literature is that, generally speaking, businesses are proponents of expansive immigration policies. Before treating this claim as an assumption, I discuss its relevance and raise an important qualification along the following lines. I contend that the preferences of businesses over the skill composition of immigration are conflicting, depending on which type of skills are used most intensively in each industry. Therefore, the corporate sector as a whole benefits from immigration only inasmuch as policies are designed to match the skills of newcomers with the specific needs of each industry.

To begin, empirical evidence from Canada brings support to the view that businesses care about the issue of immigration. Indeed, public data archived by the Office of the Commissioner of Lobbying reveal that the business sector has been actively lobbying on the specific subject matter of immigration. Between 1996 and 2011, 2462 registration records were filed either by individual firms or by interest groups representing business interests to address the topic of immigration with public officials. Moreover, the preference of the Canadian Chamber of Commerce (CCC), a major association representing industries, has been stated openly. In its recent publication titled *Top 10 Barriers to Competitiveness*, the CCC explains that the very first such barrier to competitiveness in Canada is a skills crisis, caused by a "growing labour shortage," and to which one desirable response would consist of "improving access to foreign workers" (CCC, 2012, 2). But the organization clearly emphasizes the role of skills, having a preference for foreign workers whose skills would match the requirements of the Canadian economy. For instance, they argue that "[t]he country falls short in addressing the current and future skills needs of the workplace" (CCC, 2012, 4).

The idea that firms benefit from immigration stems from the relationship between factor supply and factor price (see, for instance, Borjas, 1995). An important stream of literature on the economics of immigration builds upon the Heckscher-Ohlin model to predict the impact of labour movements on factor prices. Basically, countries where labour is relatively scarce are expected to attract workers from countries where labour is abundant. As a result, wages go down in the recipient country and conversely in the emigrants' country. The model is discussed at length in Hatton and Williamson Hatton and Williamson (1994, 2005), Grubel (1994) and Krugman and Obstfeld (2002, Ch. 7), and tested empirically in O'Rourke, Taylor, and Williamson (1996) and Taylor and Williamson (1997).

However, deducing that firms are supportive of immigration because of its expected impact on the price of labour would obscure an important point: national industries relying upon different intensities of each factor of production are affected asymmetrically by changes in the composition of labour. For instance, inflows of unskilled workers may benefit traditional industries but not high technology industries. In fact, the Rybczynski (1955) theorem implies that a sector relying less intensively on a factor may actually shrink in size following an increase in the supply of that factor. The responsiveness of output mix to factor supply change is also supported by recent empirical studies (Harrigan, 1995, 1997; Hanson and Slaughter, 1999; Gandal, Hanson, and Slaughter, 2004). Thus, it is reasonable to expect that industries are likely to advocate the admission of the specific types of labour that would advantage them most (assuming that firms are not indifferent about their size) and that they develop preferences accordingly.

A realistic assumption is that the preferences of industries are more likely to agree on the use of policy instruments that maintain the output mix by selecting migrants according to specific skill sets. This assumption is consistent with the above-mentioned statements of the CCC, insisting on the importance of skills in the selection of foreign workers. In Canada, two main policy instruments can be used for the skills-based selection of foreign workers, namely temporary work permits and economic immigration. With those qualifications in mind, I now turn to the theoretical model.

3.1.1 Policy-Making in the Presence of a Lobby

This section introduces a model depicting the decision-making process of an incumbent government facing pressures from a special interest group. As in other models of special interest politics (for example, Baron, 1994; Grossman and Helpman, 2001, Ch. 10), the government has incentives to trade policy concessions in return for the electoral support of the interest group. I consider the intensity of lobbying as an indicator of the interest group's influence on re-election prospects. I then show that in equilibrium, the incumbent is expected to shift from the ideal point of the average voter in response to lobbying efforts. However, when two policy instruments can be used as substitutes (such as permanent immigrants and temporary workers), the equilibrium solution does not imply that governments make concessions on both of them. The implication is that an empirical research design should take into account not only the response of permanent and temporary immigration levels to corporate lobbying, but also the interdependencies between those two policy instruments.

Consider an incumbent government having to choose the level of a policy instrument x in a convex, one-dimensional policy space $[A, B]$. In this case, let x represent the levels of economic migrants selected through a point system. The government observes the preference of the average voter, denoted $\bar{v}$, through public opinion polls.

Suppose that the government's objective is to secure the support of the average voter, in order to maximize its re-election chances. Let the utility of the average voter be given by the familiar quadratic utility loss function $U = -(x-\bar{v})^2$. Absent any outside intervention, the government solves $\max_x U$ and chooses $x^* = \bar{v}$.

Next, let me introduce a special interest group (SIG). A SIG is defined as an actor who 1) has a preference in the policy space that differs from $\bar{v}$, and 2) is able to significantly affect the re-election chances of the government, through political donations, elite mobilization, the conveyance of messages to the public regarding the quality of the incumbent, or independent persuasion campaigns (such as third party advertising). In this paper, the SIG uses lobbying in order to influence the government's decision-making process. Let s denote the intensity of lobbying activities. I assume that the government interprets s as a measure of the strength of the SIG, which means how influential the SIG is for re-election prospects.

Without loss of generality, and consistently with the substantive background introduced earlier, suppose that the SIG represents business interests and prefers a level of the policy greater than $\bar{v}$. Thus, $y = x - \bar{v}$ (where $y \in [0, B - \bar{v}]$) represents the size of the compromise offered by the government to the SIG.

To reflect the electoral role played by the SIG, the utility function of the average voter may be re-expressed to include the taste-shifting parameter sy^θ. In other words, sy^θ represents the shift in the preference of the average voter, given the support that the incumbent receives from the SIG with a policy concession $y > 0$. It is natural to assume $0 < \theta < 1$, i.e. that the influence exerted by a SIG on the average voter (through political donations, independent campaigning, etc.) has decreasing returns.

In short, the government faces a trade-off between the average voter's true policy preference and that of the SIG. The optimal concession y is the one for which the marginal benefit of securing the SIG's support is equal to the marginal loss resulting from unpopular policies. The objective of the government becomes:

$$\max_y U = sy^\theta - y^2, \tag{3.1}$$

and the equilibrium solution to (3.1) is $y^* = \frac{s\theta}{2}^{\frac{1}{2-\theta}}$. Given that $0 < \theta < 1$, the partial derivative $\frac{\partial y^*}{\partial s}$ is positive, which is intuitive: the stronger the lobby, the larger the equilibrium concession y^*.

The interesting case arises after introducing a second policy. Suppose that the government may now use two policy instruments, x_1 and x_2, to address a single issue. Suppose further that the average voter's preference is the same value $\bar{v}$ on both policy instruments (normalized on a common scale). The SIG still lobbies with an intensity s about both instruments, and prefers values greater than $\bar{v}$. The concessions of the government are now expressed by $y_1 = x_1 - \bar{v}$ and $y_2 = x_2 - \bar{v}$.

I denote the new government's objective with the following implicit function:

$$max_{y_1,y_2} U = f(y_1, y_2, s) - c(y_1, y_2), \tag{3.2}$$

where f is the taste-shifting function, increasing in y_1, y_2, and s; and where c is a cost function, increasing in y_1 and y_2. In line with the one-policy case, realistic substantive assumptions are that y_1 and s are complements, and that y_2 and s are also complements. The stronger the lobby, as measured by s, the greater the marginal effect of a concession y_i on the average voter's utility.

However, imposing an arbitrary functional form to (3.2) would be consequential, since the solution to the two-policy model entirely depends on the complementarity between y_1 and y_2. To see this, suppose first that y_1 and y_2 are complements. That is, the higher the level of one policy instrument (say, permanent immigrant levels), the larger becomes the marginal effect of a change in the other policy instrument (say, temporary worker levels). In this case, the objective function is supermodular in (y_1, y_2, s) (on supermodularity, see Ashworth and Bueno de Mesquita, 2006). Supermodularity entails that the signs of the comparative statics are given by the cross-partial derivatives $\frac{\partial^2 U}{\partial y_1 \partial s}$, and $\frac{\partial^2 U}{\partial y_2 \partial s}$. This means that the equilibrium choices y_1^* and y_2^* are both increasing in s, the intensity of lobbying efforts.

In contrast, if y_1 and y_2 are substitutes, then the function U is not supermodular. In this case, the comparative statics cannot be signed. The optimal policy compromise y_1^* or y_2^* could be *negatively* related to s. For instance, the indirect effect of an increase in s on the choice y_1 may offset the positive response of y_2 to s, if governments prefer to substitute y_2 by y_1. The solution depends on the nature of the interdependencies between s, y_1, and y_2. Substantively, there may be good reasons to believe that policy instruments like economic immigrants and temporary workers are substitutes, since they are closely related in purpose and nature.

Instead of arbitrarily choosing a functional form that would determine the signs of the relationships of interest, I will use an empirical strategy accounting for the interactions between the two types of immigration. At this stage, some useful theoretical expectations can be derived. First, notice that the observed policy levels are $x_1^* = y_1^* + \bar{v}$ and $x_2^* = y_2^* + \bar{v}$. Therefore, policy instruments should be positively related to the preference of the average voter. Moreover, if the levels of temporary workers and economic migrants are complements, we should observe that they are positively related to each another; in this case, they should both respond positively to lobbying. If they are instead substitutes, the impact of lobbying may affect each policy instrument in counterintuitive ways.

3.2 Data

To assess the impact of corporate lobbying on immigration in Canada, I switch to the temporal dimension and make use of quarterly data between 1996 and 2011. This section introduces the data and raises key substantive issues justifying the choice of the series. Moreover, due to legislation change during the period under scrutiny, I proceed with a careful assessment of structural breaks.

3.2.1 Economic Migrants and Temporary Workers

To measure the government's response to corporate lobbying, I consider two specific policy instruments using official and previously undisclosed quarterly data obtained by special request from Citizenship and Immigration Canada. The first immigration variable (hereafter Economic, for short) measures the quarterly inflows of permanent residents in Canada who fall under the category of economic migrants. Those are migrants selected through the Canadian point system, and their number is established using quotas by the ruling party in Parliament.[1] The second variable (hereafter Workers) measures the number of temporary work permits issued in Canada, by quarter. Both series have been transformed in natural logarithms and seasonally adjusted. They both cover the period ranging from 1996-Q1 to 2011-Q4.

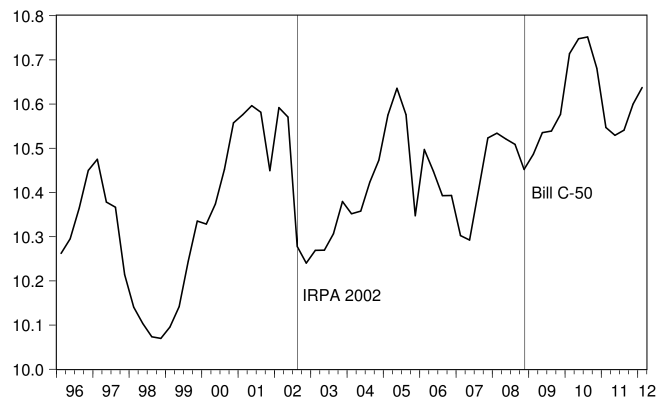
[1] Permanent immigration in Canada is a responsibility shared between the federal and provincial governments. For instance, Section 10(2) of the 2002 Immigration and Refugee Protection Act requires that the federal government meet with provinces when establishing quotas for each class of immigrants. However, the federal government remains the central authority issuing visas for permanent residence. Moreover, lobbying data availability restricts the possibility to examine corporate influence in all provinces. For those reasons, I will focus on policy making at the federal level.

Economic migrants and temporary workers differ in terms of their management. While the levels of permanent immigrants clearly fall under the authority of the government, temporary work permits are partially market driven. The standard procedure to hire foreign labour is undertaken by employers themselves since 1973, who must ask for a labour market opinion from what is now known as Human Resources and Skills Development Canada (Fudge and MacPhail, 2009). The human resources agency verifies that Canadian citizens could not fill the labour requirements before authorizing such requests. The *Immigration and Refugee Protection Act* (IRPA) of 2002 introduced dispositions increasing the government's influence. For instance, article 205 of the *Immigration and Refugee Protection Regulations* (the regulations accompanying the IRPA) grants the Minister of Immigration the power to admit temporary workers outside the labour market opinion process. Between 2002 and 2011, the annual share of work permits issued without a labour market opinion ranged between 48.6 and 63.2 per cent (CIC, 2012*b*, 67), including temporary workers admitted on the basis of international agreements. Moreover, the criteria used to evaluate economic conditions during the processing of labour market opinions, such as wage rates, are themselves a topic of contention, according to Fudge and MacPhail (2009). In theory, nothing prevents governments from adjusting those criteria through internal directives in response to pressures from employers. In fact, with the introduction of amendments to the IRPA enclosed in Bill C-50 (2008), ministerial instructions are now setting explicit caps for different occupations in the temporary foreign worker program (Abbott and Beach, 2011). Overall, there is a strong substantive justification to examine whether the inflows of temporary workers are responsive to corporate lobbying activities.

Figures 3.1 and 3.2 plot the Economic and Workers series. Quarterly inflows of economic migrants exhibit a substantial amount of variation over time, as can be observed in Figure 3.1. The series has experienced important drops during the second and third

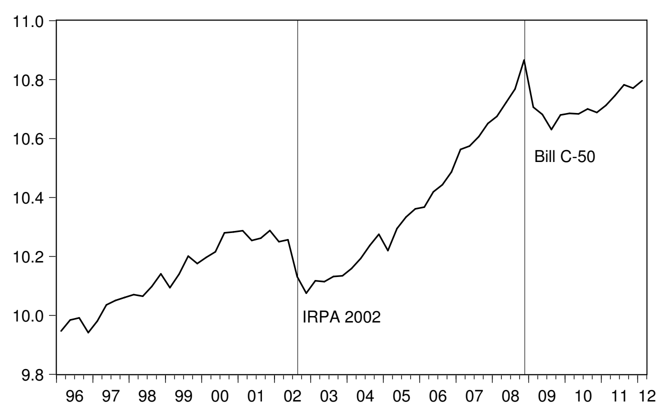
Chrétien mandates in 1998 and 2002 but appears to follow an overall increasing trend. On the other hand, the Workers series has been steadily increasing over time, although its pattern is marked by two apparent structural breaks.

Figure 3.1: Economic Permanent Resident Inflows in Canada (Quarterly, 1996Q1-2011Q4)



Seasonally-adjusted permanent resident inflows in Canada, economic category, in natural logarithms.

Figure 3.2: Temporary Worker Inflows in Canada (Quarterly, 1996Q1-2011Q4)



Seasonally-adjusted temporary worker inflows in Canada, in natural logarithms.

Distinguished on each plot by vertical lines are the sub-periods falling under different legislations. The third quarter of 2002 marks the implementation of the IRPA, which coincides with an important structural break in the Workers series, as shown in Figure 3.2.

The series temporarily dropped before returning to an increasing trend. The next important legislation comes with the amendments to the IRPA enclosed in Bill C-50. Although the bill was voted during the spring of 2008, the modifications concerning immigration came into force only during the last quarter of that year. A fall in the levels of temporary workers coincides with the implementation of those amendments. In contrast, the inflow of economic migrants has reached unprecedented heights in the ensuing years.

To account for legislation change, I include control variables in the empirical analysis that follows. Those variables are labelled IRPA and Bill C-50/Lobbying Act below, respectively for the 2002 act and the amendments in Bill C-50. They are shift dummies equalling one when the legislations are in force and zero otherwise.

3.2.2 Lobbying

I measure the intensity of lobbying by corporations on the issue of immigration using data coming from the Office of the Commissioner of Lobbying of Canada.[2] Since 1989, lobbyists in Canada are required to register their activities. Prior to the 1995 *Act to Amend the Lobbyists Registration Act*, however, actors who were lobbying without the help of professional consultants were not required to reveal detailed information on the subject matter of their activities (that is, the issue or legislation over which a lobbyist seeks to engage a discussion with a public official). From 1996 on, all individuals or corporations undertaking lobbying activities—whether or not they hired the services of professional lobbyists—were compelled to disclose the subject matter.

From the full office's database for the period 1996-2011, I used the 5064 registration

[2]I acknowledge the generous assistance of Gillian Cantello, Director of registration and client services at the Office of the Commissioner of Lobbying, in the collection of the data used in this paper, and for valuable information regarding the history of the Lobbying Act. The content of this paragraph is also based on Canada (2011*a*).

records from entities who lobbied public officials on the specific subject matter of immigration. Although an initial coding of lobbyist types (consultant, corporation or organization) was provided, I have recoded all entries according to a new categorical variable. Each lobbyist was classified as 1) a business corporation *or* an organization whose primary purpose is to represent the interests of firms; 2) professional associations and labour unions; 3) all other organizations..[3] The count of lobbyists falling in the first category was used to construct the corporate lobbying series, referred to as Lobbying below. The variable measures the total number of active records from corporate lobbies on the issue of immigration, per quarter.[4] Again, this variable has been log-transformed and seasonally adjusted. I should point out that available data on lobbying have a few limitations. For instance, expenditures on lobbying are not publicly disclosed, and it is not possible to track down the precise date of communications between lobbyists and public officials before 2008. Nevertheless, the Lobbying series should provide a meaningful measure of the variation in the intensity of lobbying activities, and it comes from the most comprehensive database available to date in Canada.

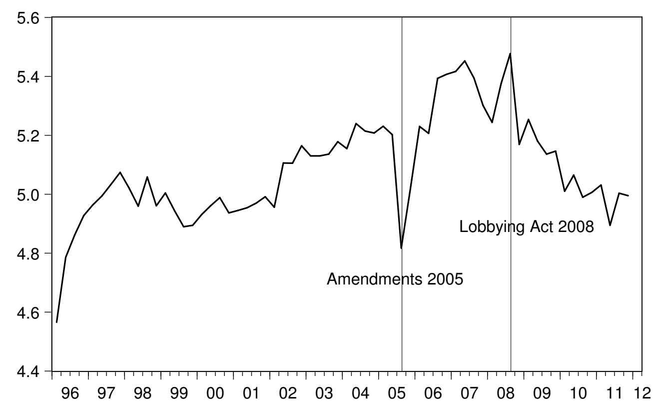
Figure 3.3 plots the Lobbying series. The variable followed an overall increasing trend since 1996, except for the most recent period. Again, two structural breaks affecting the series appear to coincide with relevant legislation change. . First, in late June 2005, a new *Act to Amend the Lobbyists Registration Act* was implemented, introducing two key

[3]Across the whole period from 1996 to 2011, 49% of the lobbyists on the issue of immigration were from the corporate sector, 23% were professional associations or unions, and the remaining were other organizations.

[4]Registration records were included even if active only during a fraction of a quarter. The same rule has been applied consistently across the whole time period. I also considered two alternative measures of corporate lobbying: 1) the count of new registration records per quarter (rather than the sum of all active records) and 2) a replication of the Lobbying series in which active records were weighted to account for the importance of corporate actors (weights were based on the total number of records registered by each lobbyist during the whole time-period). Since the conclusions are similar when replicating the empirical analysis using those alternative indicators, I will focus exclusively on the most straightforward measure introduced in the text.

modifications to the registration procedure (Canada, 2011*a*). On the one hand, some forms of communication between lobbies and public officials were now excluded from the registration requirement, like simple requests for information. On the other hand, the length of a registration record was fixed to six months, meaning that lobbyists must now file a new registration record in order to pursue their activities for a period longer than six months. To account for this break, a shift dummy labelled Amendments is included in the empirical analysis as a necessary control. It has the value of one starting at 2005-Q3 and zero otherwise.

Figure 3.3: Corporate Lobbying on the Issue of Immigration in Canada (Quarterly, 1996Q1-2011Q4)



Seasonally-adjusted number of active registration records from corporate lobbyists on the issue of immigration in Canada, per quarter, in natural logarithms.

Second, a new lobbying act came into force during the third quarter of 2008. This act coincides with an apparently sustained drop in the number of corporate lobbies on the issue of immigration. The somewhat more stringent requirements imposed on lobbyists may in part explain the reduction in the count of active lobbies. Because the implementation of the lobbying act coincides with another legislative change (the previously mentioned amendments to the IRPA in Bill C-50), only one control variable is used to account for both changes introduced earlier as Bill C-50/Lobbying Act. Including two dummy variables that are identical but for one quarter would unnecessarily reduce the efficiency of empirical estimates, and tests revealed that this has no consequence on the findings presented below.

3.2.3 Average Voter's Preference and Control Variables

To measure the preference of the average voter (labelled $\bar{v}$ in Section 3.1), I consider survey questions tackling preferences over immigration in Canada. To my knowledge, there has been no systematic measure over time of the public's preference concerning temporary workers specifically. Thus, I focus only on opinion about immigration in general. Table 3.1 presents the evolution of public opinion on immigration in Canada from 1993 to 2011. Tpresents the evolution of public opinion on immigration in Canada from 1993 to 2011. The data come from surveys of the Canadian Election Studies (CES), which have consistently queried respondents over time. The question labelling has been virtually the same since 1993, and asks, "Do you think Canada should admit: 'more immigrants', 'fewer immigrants', or 'about the same as now?'" Weighted proportions are shown in the first three columns of Table 3.1. As can be observed, while in 1993 an overwhelming share preferred a decrease in immigration inflows, respondents have been more likely to choose the middle response category since then. Respondents supportive of expansive immigration policies tend to remain a minority.

Overall, the average voter can be located as leaning in the "fewer" response category, as shown in the fifth column of Table 3.1. II have used a numerical conversion of categories to retrieve the mean from the ordinal scale. Values of the mean lower than 1 indicate that the average respondent's estimated position tends toward the restrictive side of the immigration policy spectrum. This figure merely reflects the balance of voters around the middle category, which tilts toward the "fewer" response. The 95% confidence intervals are

Table 3.1: Public Opinion on Immigration in Canada (1993-2011)

Year	More	Same	Fewer	N	Mean	Mean CI
1993	17.36%	16.86%	60.50%	3775	0.545	[0.515, 0.574]
1997	8.63	40.79	46.18	3949	0.607	[0.583, 0.632]
2000	14.20	47.15	35.20	3513	0.782	[0.756, 0.809]
2004	16.41	49.75	29.15	4323	0.866	[0.843, 0.890]
2006	15.40	55.20	23.56	4058	0.913	[0.890, 0.937]
2008	13.80	55.29	24.72	3689	0.884	[0.854, 0.913]
2011	10.52	57.96	27.64	3362	0.822	[0.796, 0.848]

The table reports the weighted proportions of respondents in CES' campaign surveys saying that they prefer more immigrants in Canada, the same level, or fewer, respectively. Weighted means (using a variable with categories coded Fewer = 0, Same = 1, More = 2) are reported along with the 95% confidence intervals. Values lower than 1 indicate that the estimated location of the average voter is on the "Fewer" side of the midpoint.

reported in the last column. Despite the temporal increase in the number of respondents choosing the middle response category until 2008, the preferred policy position of the average voter has been to reduce the immigration flows during the whole period within the bounds of statistical significance. Thus, when compared against the overt position of the CCC mentioned earlier, the public appears to disagree with the corporate sector.

Unfortunately, there exists no consistent quarterly series of public opinion on immigration in Canada during this period. Analysing the dynamics of voter preference is therefore impossible. But this also implies that governments themselves are probably unaware of short-run fluctuations in public opinion; they realistically have a general idea of the location of the average voter during their mandates. To control for the preference of the average voter, I construct a variable that corresponds to the mean response to the survey question, the values of which being shown in the fifth column of Table 3.1. This variable is called Average Voter Preference below.

Lastly, I consider two additional control variables accounting for regime change. The first is an indicator of the party in power, labelled Liberal, which equals one if the government is formed by the Liberal Party of Canada and zero if formed by the Conservative Party of Canada. I also consider the implementation of Bill C-24, which came in force in 2003-Q3 and introduced an important restriction to party finance in Canada, namely a ban on corporate donations. If governments are responsive to corporate lobbies due to electoral considerations, then the introduction of Bill C-24 should indirectly affect the influence of lobbies. A dummy variable labelled Bill C-24 accounts for this change.

3.3 Empirical Analysis

I begin the empirical analysis by examining the bivariate associations between Lobbying and each of the two immigration series. Table 3.2 reports cross-correlations up to 12 leads and lags of the Lobbying variable. In other words, those are correlation coefficients between the intensity of lobbying i periods in the past (or i periods in the future) and observed policy outcomes. A correlation is considered significantly different from zero if the coefficient exceeds the absolute value of $\frac{2}{\sqrt{T}}$, which means approximately 0.25 with $T = 64$.

The first column of Table 3.2 suggests a positive association between the lags of Lobbying and the Economic variable, significant after one year. This one-year delay could be explained by the fact that quotas of permanent residents are usually set on a yearly basis by the government. On the other hand, the leads of Lobbying are not significantly related to the Economic variable (for the most part), suggesting that the relationship is one-sided. The last two columns of Table 3.2 report the cross-correlations using the Workers series. This time, the lags of Lobbying are positive and significant for the whole period, even in the short-run. Inflows of foreign workers are also significantly related to the leads of Lobbying up to two periods ahead. Overall, those cross-correlations represent preliminary evidence consistent with the view that immigration levels in Canada are positively affected

Table 3.2: Cross-Correlations between Lobbying and Types of Immigration

	Economic, Lobbying($t \pm i$)			Workers, Lobbying($t \pm i$)	
i	Lag	Lead	i	Lag	Lead
0	0.081	0.081	0	0.446*	0.446*
1	0.102	0.042	1	0.489*	0.360*
2	0.093	0.066	2	0.514*	0.308*
3	0.171	0.089	3	0.556*	0.242
4	0.254*	0.109	4	0.571*	0.194
5	0.334*	0.146	5	0.592*	0.155
6	0.429*	0.201	6	0.622*	0.121
7	0.516*	0.221	7	0.639*	0.093
8	0.526*	0.250*	8	0.656*	0.075
9	0.521*	0.263*	9	0.644*	0.047
10	0.522*	0.224	10	0.633*	0.007
11	0.525*	0.214	11	0.625*	0.004
12	0.518*	0.222	12	0.613*	–0.031

Cross correlations between corporate lobbying and economic migrants (left panel), and temporary workers (right panel), for up to 12 lags and leads of the Lobbying series. Correlations are considered significant if they exceed the value of $\pm\frac{2}{\sqrt{T}} = 0.25$ ($T = 64$).

by corporate lobbying. But the robustness of those relationships must now be assessed using a multiple time series framework, after controlling for legislation change.

Because of its flexibility and properties, I rely upon the vector autoregression (VAR) approach developed by Sims (1972, 1980), which consists of a system of equations where each series is treated as endogenous. The VAR methodology avoids the reliance on arbitrary identification assumptions altogether. It also enables the use of Granger causality tests to examine the direction of causal relationships. Moreover, VARs permit to distinguish between short-run and long-run effects.

Consider a VAR system with the structural form:

$$\mathbf{A}_0\mathbf{y}_t = \mathbf{V} + \sum_{i=1}^{q} \mathbf{A}_i\mathbf{y}_{t-i} + \mathbf{B}\mathbf{x}_t + \mathbf{e}_t, \tag{3.3}$$

where $\mathbf{y}_t = (\text{Lobbying}_t, \text{Workers}_t, \text{Economic}_t)'$, $\mathbf{x}_t = (\text{IRPA}_t, \text{Bill C-50/Lobbying Act}_t, \text{Amendments}_t, \text{Average Voter Preference}_t, \text{Liberal}_t, \text{Bill C-24}_t)'$, q is the lag length, $\mathbf{V}$ is a matrix of intercepts and time trends, and $\mathbf{e}_t$ a vector of residuals. The matrices $\mathbf{A}_0$, $\mathbf{A}_i$, and $\mathbf{B}$ contain the parameters of the VAR's structural form.

Since the system of simultaneous equations in 3.3 is not identified, the structural form cannot be estimated. Instead, VAR analysis consists of estimating the reduced form equations, which correspond to:

$$\mathbf{y}_t = \mathbf{D} + \sum_{i=1}^{q} \mathbf{\Pi}_i\mathbf{y}_{t-i} + \mathbf{\Theta}\mathbf{x}_t + \mathbf{u}_t, \tag{3.4}$$

where $\mathbf{\Pi}_i$ and $\mathbf{\Theta}$ are the matrices of reduced form parameters. Of course, the estimated coefficients in $\mathbf{\Pi}_i$ and $\mathbf{\Theta}$ are not interpretable individually. However, the short- and long-run relationships between the series can be simulated using forecast error impulse responses and orthogonalized impulse responses. Both techniques are used below.

The next subsections go over the key steps of the VAR methodology, including unit root testing, lag length selection, and impulse response analysis.

3.3.1 Unit Root Tests

Testing variables for unit roots (that is, for the existence of a time-dependent mean and variance) has become the starting point of time-series analysis to prevent the potential issues that may result from regression models including non-stationary variables (Granger and Newbold, 1974). Therefore, I proceed with unit roots tests on the Lobbying, Workers, and Economic series. The results of Augmented Dickey-Fuller (ADF) unit root tests are reported in Table 3.3, for lag lengths between 0 and 8. All tests include a time trend and a constant. The null hypothesis is that the series contains a unit root.

Table 3.3: Augmented Dickey-Fuller Unit Root Tests

				With Structural Breaks	
Lags	Economic	Workers	Lobbying	Workers	Lobbying
0	–2.604	–1.726	–3.142†	–5.496**	–5.834**
1	–3.345†	–1.761	–2.204	–5.206**	–4.605**
2	–3.156†	–1.828	–1.709	–4.975**	–4.124**
3	–4.083**	–1.772	–1.786	–4.717**	–4.736**
4	–3.678*	–1.961	–1.496	–4.602**	–4.385**
5	–3.705*	–2.318	–1.552	–4.507**	–4.403**
6	–4.560**	–2.446	–1.261	–4.305**	–3.795*
7	–4.202**	–2.693	–1.040	–4.289**	–3.223†
8	–2.944	–1.979	–0.980	–3.425*	–2.574

Augmented Dickey-Fuller unit root tests of the null of non-stationarity, including intercepts and trends. The last two columns are the t-statistics from ADF regressions including two trend shifts to account for structural breaks. The breaks have been located at 2002-Q3 and 2008-Q4 for the Workers series, and at 2005-Q3 and 2008-Q4 for the Lobbying series (see discussion in text). The critical values are –3.96, –3.41, and –3.13, respectively for the 0.01, 0.05, and 0.10 significance levels. **: $p < 0.01$, *: $p < 0.05$, †: $p < 0.10$.

The first column of Table 3.3 shows that the series on economic immigrant inflows appears trend-stationary for most of the lag lengths considered. The Akaike information criterion (AIC) suggests that the appropriate lag length is 6. Using 6 lags, the null hypothesis is clearly rejected at the $p < 0.01$ significance level, confirming the verdict of trend stationarity. On the other hand, as shown in the second and third columns of the table, the null hypothesis of a unit root holds for the Workers and Lobbying series, under various lag lengths, at the 0.05 significance level.

However, the earlier graphical inspection of Workers and Lobbying pointed to the existence of important structural breaks. In the presence of structural breaks, ADF unit root tests are known to be biased in favour of accepting the null hypothesis (Perron, 1989; Enders, 2010). Therefore, and following the approach in Perron (1989), I devised ADF unit root tests including trend shifts starting at the time of each of the two major structural breaks. I created interaction terms by multiplying the time trend with the IRPA and Bill C-50/Lobbying Act variables, and included those terms in the Workers ADF regression. I did the same with the Amendments and Bill C-50/Lobbying Act variables in the Lobbying ADF regression. Columns 4 and 5 of Table 3.3 report the ADF test statistics accounting for structural breaks, which are evaluated against the same critical values used earlier.

Once accounting for structural breaks, the test statistics support the conclusion that both time-series are trend stationary. This verdict holds for most lag lengths. Thus, I treat all endogenous variables in the following analysis as stationary.

3.3.2 Lag Length Selection

A sensitive step in VAR analysis is the selection of the number of lags to include in the model. Insufficient lags can leave important dynamics out of the model, whereas excessive lags reduce the efficiency of estimates by taking away degrees of freedom.

As a starting point, I consider a rule of thumb stating that the lag length q should cover at least a full cycle of the data's periodicity, even when the series are seasonally adjusted (Brandt and Williams 2007, 25). Since I am using quarterly data, this means that an ideal lag length would be at least 4. On the other hand, q is limited by sample size, which amounts to only 64 observations, and the use of eight deterministic terms already consumes degrees of freedom. Thus, I consider searching for an optimal lag length between 4 and 8.

Table 3.4 reports four common measures to select lag length: the AIC, the Bayesian (Schwarz) information criterion (BIC), the Hannan-Quinn information criterion (HQC), and the final prediction error (FPE). The lowest value for each statistic indicates the optimal q. As Table 3.4 shows, the optimal lag length depends on the criterion considered. The AIC and FPE statistics suggest choosing larger lag lengths, 8 and 5, respectively. In contrast, both the BIC and HQC recommend the most parsimonious model, with 4 lags. On the positive side, notice that I have tested VAR models with each of the lag lengths between 4 and 8, and the impact on the results that I will present below is negligible. I choose to focus on a VAR model with 6 lags, denoted VAR(6), which represents a compromise between the optimal lag lengths suggested by the four information criteria.

Table 3.4: Lag Length Selection Criteria

Lag Length	AIC	BIC	HQC	FPE
4	–17.101	–15.006	–16.281	4.053e–08
5	–17.193	–14.763	–16.244	3.890e–08
6	–16.952	–14.181	–15.873	5.334e–08
7	–17.098	–13.980	–15.886	5.136e–08
8	–17.316	–13.844	–15.970	4.827e–08

The Table reports the Akaike information criterion (AIC), the Bayesian (Schwarz) information criterion (BIC), the Hannan-Quinn information criterion (HQC), and the final prediction error (FPE) for VAR models of various lag lengths. In each case, the lowest value indicates the optimal lag length.

3.3.3 VAR Estimates and Goodness-of-Fit

I now turn my attention to the adequacy of the chosen specification. Table 3.5 reports goodness-of-fit statistics and tests of the normality of residuals for each equation in the VAR(6) model. The adjusted R^2s and the standard errors of the regressions suggest that the Workers equation produces the best fit among the three. Put another way, the forecast of temporary worker inflows is especially efficient. Of particular importance are the normality tests for the residuals (Jarque-Bera tests for residuals from each equation, and the Lütkepohl's joint normality test for the whole model). Non-significant statistics indicate that residuals have been efficiently purged out from serial correlation. As can be observed in Table 3.5, the VAR(6) model efficiently incorporates the dynamics, and all of the residuals are normally distributed.

I also report the VAR estimates. Recall that those are reduced form parameters and should not be considered accurate point estimates. They are sometimes interpreted for signs, however. Of interest is the positive association between the Average Voter Preference and the Economic variable, although the relationship is short of statistical significance (this estimate is significant in the VAR(8) specification). In contrast, the Workers series does not appear to follow meaningfully the trends in the average voter opinion. As for the dynamics between the endogenous variables, I address them below using impulse response analysis.

3.3.4 Granger Causality

I perform Granger causality tests to address the direction of causality between the three endogenous series. The interest is to confirm whether corporate lobbying has a causal effect on policy outcomes, rather than the other way around. The idea behind Granger

Table 3.5: VAR Reduced Form Estimates and Goodness-of-Fit Statistics

	Equation		
Variable	Lobbying	Workers	Economic
$\sum_{i=1}^{6}$ Lobbying$_{t-i}$	0.134	0.215	0.037
	(0.223)	(0.121)	(0.256)
$\sum_{i=1}^{6}$ Workers$_{t-i}$	0.708	0.567	–0.238
	(0.376)	(0.203)	(0.433)
$\sum_{i=1}^{6}$ Economic$_{t-i}$	0.081	–0.059	0.379
	(0.167)	(0.090)	(0.192)
IRPA (2002)	0.181	–0.156	–0.197
	(0.074)	(0.040)	(0.085)
Bill C-50 / Lobbying Act (2008)	–0.294	–0.045	0.031
	(0.070)	(0.038)	(0.081)
Amendments (2005)	–0.306	0.056	–0.122
	(0.063)	(0.034)	(0.073)
Average Voter Preference (Log)	0.053	–0.222	0.454
	(0.202)	(0.109)	(0.232)
Liberal	–0.382	0.002	–0.075
	(0.081)	(0.044)	(0.093)
Bill C-24	0.249	0.011	–0.018
	(0.110)	(0.059)	(0.126)
Intercept	–3.326	4.736	6.688
	(2.959)	(1.600)	(3.404)
Trend	–0.014	0.010	0.009
	(0.006)	(0.003)	(0.007)
R^2	0.917	0.990	0.904
Adj.-R^2	0.853	0.982	0.829
Standard Error of Regression	0.061	0.033	0.071
Jarque-Bera Normality Test	1.107	1.532	0.508
p-value (Jarque-Bera)	0.575	0.465	0.776
Log-likelihood		322.72	
AIC		–16.952	
BIC		–14.181	
Lütkepohl's Joint Normality Test		3.175	
p-value (Lütkepohl)		0.787	

OLS estimates for each equation of the reduced form VAR(6) model, with standard errors in parentheses.

causality tests is to assess whether the past values of a variable significantly improve the contemporaneous prediction of another variable, controlling for the past values of the predicted variable (Granger, 1969). With two endogenous series, Granger causality tests can be readily implemented in a VAR analysis. With three endogenous series, it is possible to partition the VAR model into two groups, each containing a subset of the three variables (see Lütkepohl, 2005).

The first three rows of Table 3.6 report Granger causality tests based on the main VAR(6) specification. The table shows Wald tests of the null of Granger non-causality, along with the p-values. As can be seen, none of the series causes the group composed of the two others. However, it is perhaps more interesting to learn whether a variable causes an individual series (rather than a group of two series). For this purpose I have estimated bivariate VAR(6) models. Those bivariate VARs are identical to the main specification in every respect, except for the fact that they each include one pair of endogenous series at a time. The results are presented straightforwardly in the bottom rows of Table 3.6. Only one test is statistically significant at the 0.05 confidence level: Lobbying has a causal impact on Workers. This result is consistent with the argument developed in this paper. On the other hand, Lobbying does not appear to have a significant causal effect on the Economic series.

3.3.5 Impulse Response Analysis

To examine the dynamics between endogenous series, the VAR methodology relies upon impulse response analysis. Impulse responses can be viewed as estimates of the effect of variables on each other, over time. Basically, impulse responses are coefficients in the moving-average representation of a VAR model (see Lütkepohl, 2005; Enders, 2010).

Table 3.6: Granger Causality Tests

Multivariate VAR		
Direction of Causality	Wald Test	p-Value
Lobbying → Workers, Economic	1.369	0.194
Workers → Lobbying, Economic	0.765	0.684
Economic → Lobbying, Workers	1.366	0.196

Bivariate VARs		
Direction of Causality	Wald Test	p-Value
Lobbying → Workers	3.062	0.010
Workers → Lobbying	0.933	0.476
Lobbying → Economic	0.631	0.705
Economic → Lobbying	1.018	0.420
Workers → Economic	0.857	0.530
Economic → Workers	1.980	0.079

The table reports Wald tests of the null of Granger non-causality, along with p-values.

For instance, consider the moving-average representation

$$\mathbf{y}_t = \boldsymbol{\mu} + \sum_{i=0}^{\infty} \boldsymbol{\Phi}_i \mathbf{u}_{t-i}, \tag{3.5}$$

where $\boldsymbol{\mu}$ contains the means of the $\mathbf{y}_t$ series. For any two variables j and k, the moving-average coefficients in the $\boldsymbol{\Phi}_i$ matrices depict the response of a series y_j to a shock in the residuals u_k of equation k. Those coefficients are also interpretable as the response of a y_j series to a shock in the y_k series having occurred i periods in the past.

I consider two different types of impulse responses. First, the matrices $\boldsymbol{\Phi}_i$ in (3.5) can be computed using the method described in Lütkepohl (2005, Ch. 3), yielding coefficients called forecast error impulse responses. This method restricts the contemporaneous effects to zero, and simulates responses to a shock in one series while holding the other residuals to zero. There is no assumption regarding the exogeneity of the series.

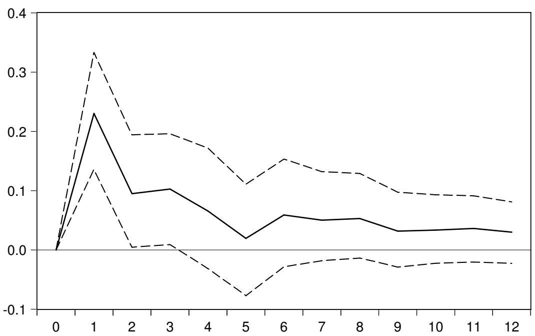
The second method is called orthogonalized impulse responses. Here, the researcher uses identification assumptions to estimate the residuals of the structural form: in the trivariate case, one variable is assumed exogenous to the system, and a second variable is assumed exogenous to the third (see Enders, 2010, 307-11). This is called a Cholesky decomposition. In contrast to the previous method, contemporaneous effects are allowed, which means that impulse responses provide a better depiction of the dynamics. The downside is that the Cholesky ordering of the variables (from exogenous to endogenous) matters, and may affect the results.

Figure 3.4 shows the forecast error impulse responses based on the VAR(6) model. I focus on the four relationships of interest (over the nine possible combinations). The vertical axis of each plot measures the response of a variable to a one unit increase in another variable at time 0, everything else being equal. The responses can be tracked over time, up to 12 quarters ahead. Since I use variables in natural logarithms, the responses can be conveniently interpreted as elasticities: the coefficients of the impulse response functions represent the percentage change in a response variable for a one percent increase in another variable. In each subplot of Figure 3.4, the title indicates the direction of the relationship. To assess statistical significance, each plot includes Hall's bootstrapped 95% error bands (computed using 1000 bootstrap replications). I will use the same type of error bands throughout the rest of the text.

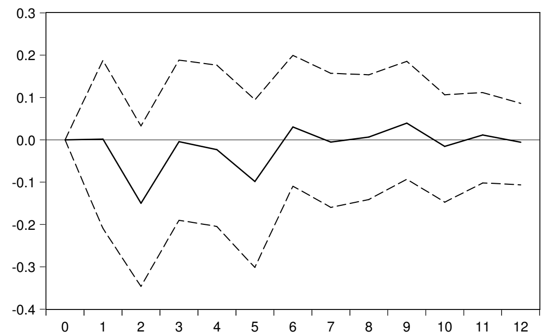
Focusing on the upper-left plot of Figure 3.4, the estimated impact of Lobbying on the Workers series appears positive and significant. The short-run elasticity in the first quarter following a change in Lobbying corresponds to 0.23. Short-run responses of the Workers variable remain positive and statistically significant for about one year. In contrast, the responses of Economic to a 1 per cent shock in Lobbying, depicted in the upper-right plot, cannot be distinguished from zero. The two plots at the bottom of Figure 3.4, illustrate

Figure 3.4: Forecast Error Impulse Responses

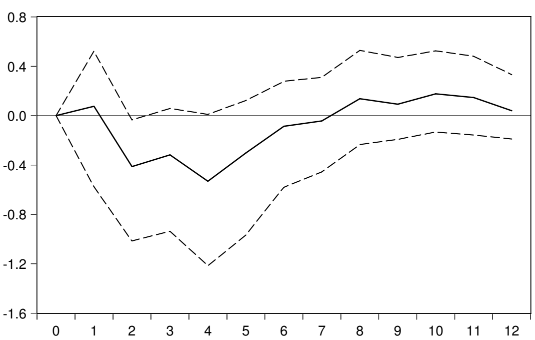
(a) Lobbying → Workers



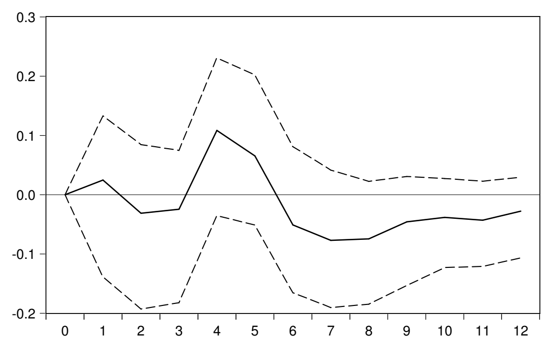
(b) Lobbying → Economic



(c) Workers → Economic



(d) Economic → Workers

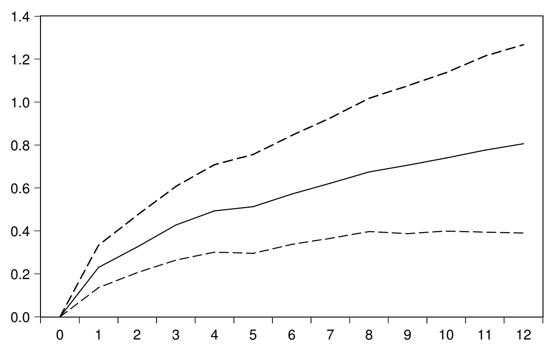


the interdependencies between the Workers and Economic series. As can be seen, inflows of economic migrants respond negatively to innovations in the levels of temporary workers after two quarters. This finding supports the hypothesis that economic migrants and temporary workers are substitutes rather than complements. On the other hand, the Workers series appears unresponsive to changes in the Economic series.

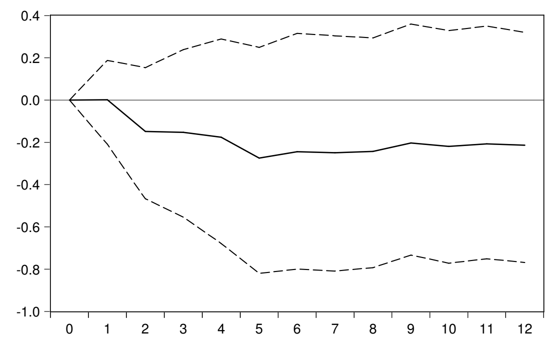
Of course, it is also interesting to have an estimate of the overall response of a variable. Long-run effects can be computed by cumulating impulse responses over time and are depicted in Figure 3.5. SSince the short-run effects of one variable on another wear off over time, accumulated responses converge to a value that can be interpreted as the long-run impact. Here, I consider the accumulated response after two years. The two-year long-run elasticity of the Workers variable with respect to Lobbying corresponds to 0.67. That is, a 1 per cent increase in corporate lobbying activities leads to an estimated 0.67% increase in temporary worker inflows, all else being equal, distributed over a period of two years. Expectedly, the cumulative impact of Lobbying on Economic is zero on the long run, as shown in the upper-right plot of Figure 3.5.

Figure 3.5: Accumulated Forecast Error Impulse Responses

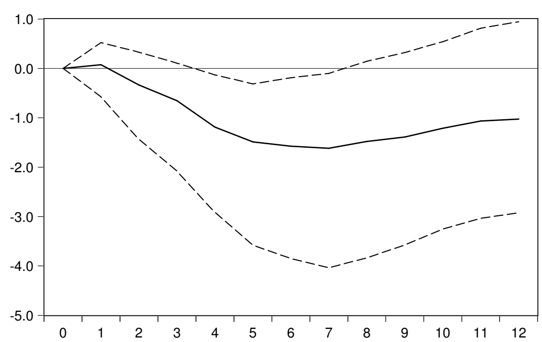
(a) Lobbying → Workers



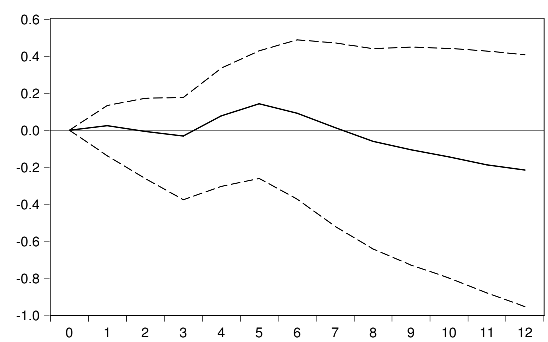
(b) Lobbying → Economic



(c) Workers → Economic



(d) Economic → Workers



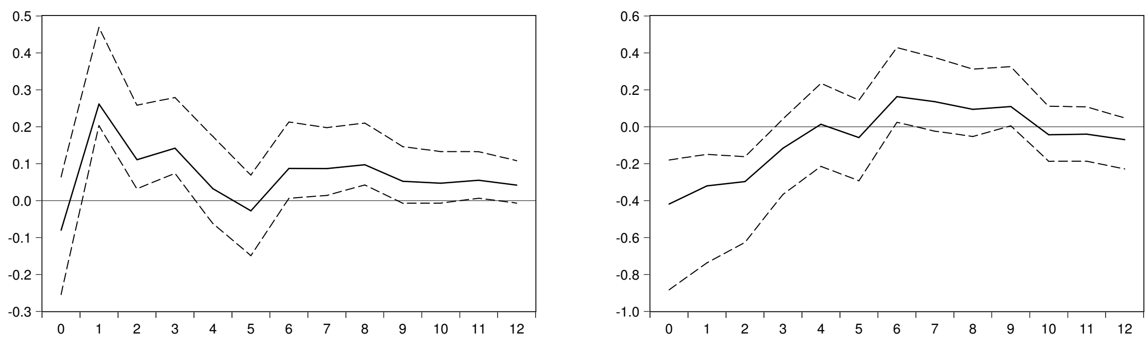
I now turn to the alternative approach, orthogonalized impulse responses, to verify whether the results hold. I use the Cholesky ordering Lobbying → Workers → Economic, from the most exogenous to the most endogenous. This choice is consistent with the theory introduced earlier.

Figure 3.6 reports the orthogonalized impulse responses for the two relationships of interest. Coefficients still represent responses to a unit shock in the original series, and correspond to elasticities. Starting with the impact of Lobbying on the Workers series, the one-step ahead short-run elasticity is 0.26, virtually the same as before. The short-run effects remain positive and significant for approximately two years, except between lags 4 and 6. There is no evidence of a significant contemporaneous effect. The cumulative elasticity after two years is 0.53, compared to the value of 0.67 found earlier (for simplicity of presentation, the cumulated responses are not reported in figures).

Figure 3.6: Orthogonalized Impulse Responses

(a) Lobbying → Workers

(b) Lobbying → Economic



As for the response of Economic to changes in Lobbying, it now appears ambiguous. The response is initially negative but becomes positive and significant about a year and a half after the initial shock before fading off. In sum, there is no clear evidence that the intensity of corporate lobbying positively affects the inflows of economic permanent immigrants in Canada.

Overall, the empirical findings reported so far suggest that the inflows of temporary workers are most responsive to lobbying efforts from the business sector. Short-run effects are positive and significant, and the cumulative long-run elasticity (computed after two years) varies between 0.53 and 0.67. This means that a 10% increase in the number of corporate actors lobbying on immigration is associated with a long-run increase ranging between 5.3 and 6.7% in the number of temporary work permits per quarter. Using the mean values of each of the two variables for illustrative purposes, this example corresponds to the addition of 16.3 new active corporate lobbyists (compared to the sample average of 163 per quarter) and an associated increase in the number of temporary work permits between 1750 and 2220 (compared to an average of 33,100). Moreover, this relationship is Granger causal.

3.3.6 Accounting for the Labour Market

The previous result is surprising given that the management of work permits in Canada can be expected to partially fall outside the scope of direct political influence. To test the robustness of this result, I replicate a VAR model including the rate of unemployment as an endogenous regressor, along with the Lobbying and Workers variables.[5] The goal is to find whether the impact of lobbying remains significant after accounting for the share of work permits depending primarily on market conditions. Due to sample size limitations, unemployment could not be readily included in the previous specification.

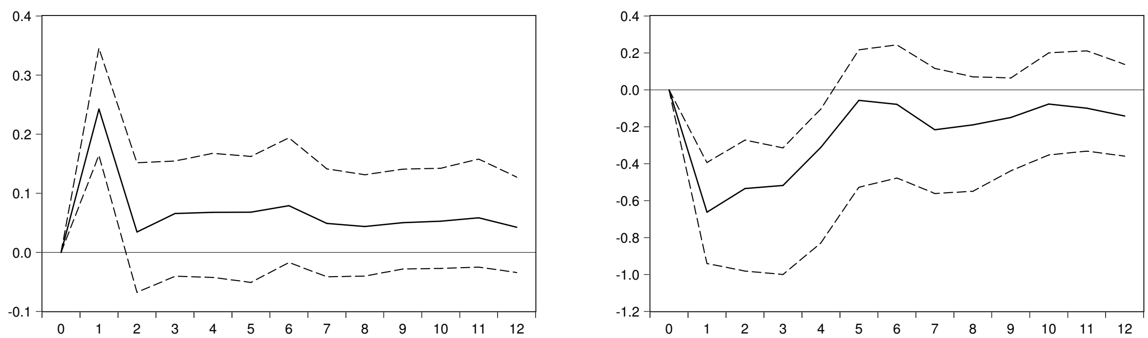
For consistency, the new model includes the same deterministic terms as before and is computed with six lags. Figure 3.7 reports the forecast error impulse responses of the new VAR. The figure includes the two relationships of interest to understand the inflows of temporary workers in Canada. The response of Workers to Lobbying exhibits a similar

[5]This series comes from Statistics Canada (Canada, 2012*a*). Unadjusted monthly values were averaged by quarter. The series was then transformed in natural logarithms and seasonally adjusted. Unit root tests performed on this variable produce mixed results. A recent article suggests that the unemployment series in Canada is trend stationary once accounting for structural breaks (Ewing and Wunnava, 2001). For the purpose of this study, I will treat this series as stationary.

pattern as before. The estimated short-run elasticity after one quarter is 0.24, close to the value of 0.23 found using the previous specification. The cumulated elasticity after two years is 0.65, compared to the 0.67 obtained before. Moreover, the relationship from Lobbying toward the pair composed of Unemployment and Workers is Granger causal (with a Wald test statistic of 2.03 and a p-value of 0.03).

Figure 3.7: Forecast Error Impulse Responses, Alternative VAR Specification

(a) Lobbying → Workers (b) Unemployment → Workers

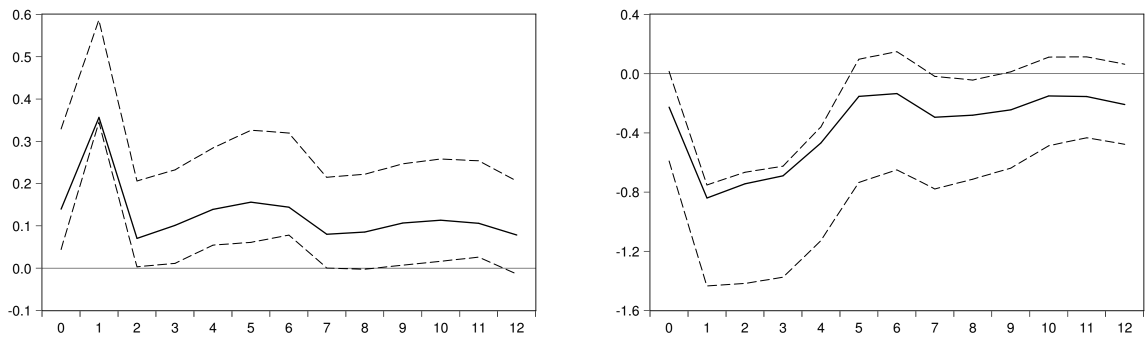


Unsurprisingly, shocks in the rate of unemployment lead to a negative and significant response of the number of temporary work permits, as depicted in Figure 7(b). When the rate of unemployment falls, meaning that national labour becomes scarcer, a greater number of work permits are issued, since this stimulates the market-driven process of temporary worker admission. When unemployment rises, temporary worker inflows go down.

When replicating using orthogonalized impulse responses, as depicted in Figure 3.8, the main finding also holds (I made use of the Cholesky ordering Unemployment → Lobbying → Workers). In fact, point estimates appear magnified, which is due to the existence of a positive and significant contemporaneous impact of Lobbying on Workers. The one-step ahead elasticity for the relationship Lobbying → Workers is 0.36, and the short-run effects appear to persist for nearly two years. The long-run elasticity after two years is 1.27, much larger than the value of 0.53 found using the previous specification.

Figure 3.8: Orthogonalized Impulse Responses, Alternative VAR Specification

(a) Lobbying → Workers (b) Unemployment → Workers



Lastly, I assess the relative importance of each factor to explain the variance in the Workers series. This method is called forecast error variance decomposition. It is especially interesting to compare how much of the variance in the Workers series is explained by market forces versus corporate lobbying. I keep the same Cholesky ordering, which also matters here. Table 3.7 reports the variance decomposition for each variable, computed after 12 periods (three years). Each row decomposes the variance of a series between the three variables mentioned in the column headers. As can be seen, 38% of the variance in the Workers series is explained by unemployment, 17% is attributable to corporate lobbying, while 44% is explained by the series itself. Thus, even after accounting for market forces, there seems to be a non-trivial part of the variation in temporary worker inflows explainable by the pressures exerted by corporations on decision makers.

Table 3.7: Decomposition of Forecast Error Variance

		Innovations In		
		Unemployment	Lobbying	Workers
Forecast Variable	Unemployment	0.96	0.02	0.02
	Lobbying	0.22	0.70	0.07
	Workers	0.38	0.17	0.44

Forecast error variance decomposition based on the alternative VAR(6) specification, computed after 12 periods using the Choleski ordering: Unemployment → Lobbying → Workers.

3.4 Conclusion

This paper sought to provide a systematic assessment of the claim that governments cater to corporate interests when managing immigration. Focusing on the case of Canada, I argued that two policy instruments, temporary work permits and economic immigration, are most likely to answer the specific needs of industries. I also stressed that electorally motivated governments need not make concessions on both these instruments if they can be used as substitutes. To shed light on this question, I made use of fine-grained empirical data on lobbying and immigration in Canada over time and adopted an empirical methodology avoiding the reliance on restrictive modelling assumptions by using VAR analysis.

A key finding is the positive and significant response of temporary worker inflows to the intensity of corporate lobbying on the subject matter of immigration. This relationship is Granger causal, and the conclusion holds after controlling for the role of market forces. In contrast, there is no strong evidence that lobbies are able to affect the levels of economic immigration, except when considering cross-correlations. Those results may sound counterintuitive, since temporary work permits in Canada were historically issued through a market-driven process limiting the scope of political influence, in contrast to permanent immigration. In practice, however, an important share of temporary foreign workers is admitted outside the labour market opinion process, providing enough political flexibility to adjust levels in response to outstanding requests from corporations.

The main empirical findings underscore the potentially important role played by temporary worker programs as a source of foreign labour. As argued in the theoretical section of this paper, national industries are likely to form conflicting preferences over the skill composition of immigration, since they each rely upon workers with specific skill sets. Temporary worker programs are particularly well suited to answer those specific industry needs. Indeed, temporary workers can be hired from abroad and selected based on their experience and resume. Temporary worker programs can also accommodate various types of industries, even the more traditional ones (for instance through the Seasonal Agricultural Worker Program or the Low Skill Pilot Program (see CIC, 2012*a*)). In contrast, policy makers have much less control over the actual sector of employment of permanent residents, whose status is not conditional on hiring offers. Future research could examine whether the electoral costs of temporary and permanent immigration also differ, in other words, whether voters have more favourable views regarding temporary workers than permanent immigrants. If so, this could reinforce the conclusion that temporary worker programs represent a substitute to economic immigration serving the objectives of both governments and industries.

Chapter 4

Low-Technology Industries and the Skill Composition of Immigration

Under review in the *Journal of Public Policy*.

Abstract

This paper examines the relationship between the industry mix and policy decisions about the skill composition of immigration. I argue that low- and high-technology industries are unequally affected by changes in the intensity of factors of production, and develop conflicting preferences over immigration policies. To avoid the negative reactions that would ensue from the depletion of regional industries, governments have incentives to take those preferences into account and to adjust the skill composition of immigration in order to maintain the existing regional industry mix. I test the relevance of this argument using data on Canadian provinces between 2001 and 2010, and a research design based on the two-stage least squares methodology. Overall, the empirical results are consistent with the theory: provinces relying intensively upon low-technology industries are likely to receive higher proportions of unskilled immigrants, which in turn help to maintain this specialization. A key implication is that immigration policies may slow down the growth of the high-technology sector.

The theoretical argument of this paper builds upon two ideas rarely pieced together when studying immigration policies. The first idea stems from the Rybczynski theorem in international economics, which predicts that industries are unequally affected by changes in factor endowments. For instance, unskilled immigration is expected to benefit traditional sectors of activity, at the expense of more sophisticated industries relying on skilled workers. It follows that businesses are likely to form conflicting preferences over the ideal mixture of skilled versus unskilled immigration, depending on which type of labour is used most intensively in their industry. The second idea is a well-entrenched claim in the literature suggesting that governments cater to the corporate sector when managing immigration policies (Freeman, 1995; Borjas, 2001; Tichenor, 2002; Menz, 2009). Starting from those premises, I argue that elected governments have incentives to manage the skill composition of immigration strategically, in order to optimize their support from local industries and avoid the negative attention that would result from the depletion of specific sectors. Put another way, my claim is that governments use immigration policies in an effort to maintain the status quo in the regional industry mix.

This study has few counterparts in the existing literature. Despite the scholarly attention devoted to the influence of corporate interest groups on immigration policies, rarely had quantitative studies brought forth supportive evidence linking policy outcomes with concerns for national industries. Moreover, the few examples of quantitative research along those lines have focused mostly on openness to immigration (Facchini, Mayda, and Mishra, 2011; Nicholson-Crotty and Nicholson-Crotty, 2011), rather than on decisions regarding the skill composition of immigration per se. A separate stream of works has examined the impact of immigration on the national industry mix (Hanson and Slaughter, 1999, 2002; Gandal, Hanson, and Slaughter, 2004), building upon earlier empirical accounts supporting the view that the output mix adjusts to changes in factor endowments (Harrigan, 1995, 1997; Bernstein and Weinstein, 2002). However, those studies have been devoted to the economic impact of immigration, leaving aside the political dimension of the problem. The present research contributes to this literature, by examining the policy-making aspects of the relationship between industries and the skills-based selection of immigrants.

An obvious difficulty with the research design of this paper is the simultaneity of the relationship between policy outcomes and the mix of industries. Indeed, if expectations regarding the impact of immigration on the mix of output are a motivation behind the selection of immigrants, the relationship can be viewed as a system. Testing the argument requires an estimator able to deal with simultaneous equations. I address this problem using data on Canadian provinces and a research design based on the two-stage least squares (2SLS) approach. The main results are also replicated by considering models for dynamic panel data accounting for both endogeneity and unobserved provincial effects, using the generalized method of moments (GMM). Overall, the findings are consistent with theoretical expectations, suggesting that concerns regarding the mix of low- and high-technology industries affect policy decisions about the skills-based selection of immigrants. A key implication of the argument is that immigration policies may temper down the transition toward the knowledge-based economy—i.e. the growth of sophisticated, high-technology industries relying intensively on skilled labour.

For a number of reasons, the Canadian case represents a fertile ground for research on immigration. To begin with, the country is often mentioned as a reference after having implemented in 1967 a point system facilitating the skills-based selection of immigrants (Borjas, 2001; Chiswick, 2011), a policy instrument which has inspired similar measures in countries such as Australia, New Zealand, or the United Kingdom (Hatton and Williamson, 2005; Somerville, 2007). Therefore, the results of this study should offer useful insights to scholars and practitioners from other nations in which skills-based selection mechanisms are also in place. Moreover, Canada ranks among the countries with the largest inflows of permanent residents relative to population size across the OECD (see OECD, 2012, 30-32), and it has a long history as a recipient state of mass migration. As such, the Canadian setting represents a natural laboratory for the study of immigration, and the findings of this paper may help to inform other countries having more recently adopted expansive immigration policies. Finally, Canada enjoys an immense geographical diversity, and provinces tend to differ markedly in terms of their industry mix. This provides a substantial amount of variation facilitating the use of statistical methods in order to test the central argument.

The rest of this paper proceeds as follows. The next section develops the theoretical argument in general terms. I then introduce substantive notions about Canadian policies in the second section, before presenting the research design and the empirical data. The third section discusses empirical findings and emphasizes key policy implications. A final section concludes.

4.1 Theoretical Model

Consider an economy composed of two industries. The first is a low-technology industry producing a traditional good labelled X, for instance clothing. The second is a high-technology industry producing a sophisticated good labelled Z, say, computers.

Each industry relies upon different intensities of two factors of production, namely unskilled labour (L) and skilled labour (H). Throughout this study, skilled labour refers to workers with university education, in contrast to unskilled labour. It is natural to assume that the low-technology industry uses unskilled labour most intensively, and skilled labour least intensively, relative to the high-technology industry. Formally, this means that the inequality $\frac{L_X}{H_X} > \frac{L_Z}{H_Z}$ holds, where the subscripts refer to the quantity of each factor used in the X and Z industries.

Using traditional tools of economic theory, the arrangement of the aggregate economy can be represented by imposing factor market clearing conditions:

$$a_{L,X}X + a_{L,Z}Z = L_X + L_Z = L, \tag{4.1}$$

$$a_{H,X}X + a_{H,Z}Z = H_X + H_Z = H, \tag{4.2}$$

where the input coefficients $a_{i,j}$ $(i = \{L, H\}, j = \{X, Z\})$ measure the fraction of output attributable to each factor. The well-known Rybczynski (1955) theorem provides a straightforward expectation regarding the impact of a change in the supply of either L or H, such as the one that would result from the addition of immigrant workers to the labour force. Given that $\frac{a_{L,X}}{a_{H,X}} > \frac{a_{L,Z}}{a_{H,Z}}$ stands as an inequality (which follows from the assumptions about the intensity of factors in each sector), a change in the supply of L through immigration would lead to an expansion of the industry X, which uses that factor most intensively, and to a contraction of the industry Z. The converse holds following a change in the supply of H.[1]

I contend that industries develop preferences over the selection of immigrants that are consistent with the expected impact on the output mix. Even though firms within those industries should theoretically become indifferent to the size of their activities under perfect competition, it should appear realistic to relax such a strong assumption. The shrinking in size of an industry would imply, in practice, the closure of individual firms, the loss of unmovable assets, and equity losses for investors. Thus, it is natural to think that firms prefer the type of immigration that would advantage their industry most, in order to avoid jeopardizing their activities.

[1] Grossman and Helpman (1991) have addressed a similar problem theoretically under various assumptions regarding the substitutability of factors of production.

The change in industry output following an increase in each of the two factors of production can be obtained by differentiating (4.1) and solving for the partial derivatives $\frac{\partial X}{\partial L}$ and $\frac{\partial Z}{\partial L}$. Those partial derivatives are the familiar solutions to the Rybczynski theorem:

$$\frac{\partial X}{\partial L} = -\frac{a_{H,Z}}{(a_{H,X}a_{L,Z} - a_{L,X}a_{H,Z})} > 0, \tag{4.3}$$

$$\frac{\partial Z}{\partial L} = \frac{a_{H,X}}{(a_{H,X}a_{L,Z} - a_{L,X}a_{H,Z})} < 0, \tag{4.4}$$

$$\frac{\partial X}{\partial H} = \frac{a_{L,Z}}{(a_{H,X}a_{L,Z} - a_{L,X}a_{H,Z})} < 0, \tag{4.5}$$

$$\frac{\partial Z}{\partial H} = -\frac{a_{L,X}}{(a_{H,X}a_{L,Z} - a_{L,X}a_{H,Z})} > 0. \tag{4.6}$$

Because of the intensity rankings associated with each industry, the signs of the comparative statics are straightforward. Clearly, firms of the industry X would prefer to avoid the addition of foreign labour from the skilled category, which disadvantages the industry as a whole, to the benefit of industry Z. Likewise, industry Z would rather avoid unskilled immigration, which implies a reduction of its size.

Next, let me introduce a government in charge of the selection of immigrants. To maintain the focus of this study on the role of factor intensities, I consider a situation where the absolute levels of immigration are given exogenously. The government must choose the proportion of unskilled migrants, denoted $y \in [0, 1]$ (such that the proportion of skilled migrants becomes $(1 - y)$).

Suppose that when making its decision, the government seeks to minimize the welfare loss of both industries. The rationale behind this modelling choice is relevant if one agrees with the idea that in politics, governments prefer to avoid attracting negative attention on themselves, such as the negative news that would follow the closure of firms from specific sectors of local economies. Even if industry X or Z were theoretically preferable, for instance because of an international comparative advantage, the transformation of the economy would come at a political cost. The loss of jobs and unmovable assets accompanying the depletion of a sector would direct negative attention and grievances toward the elected government, who would risk losing the support of important social actors.

Although the inner mechanism driving the government's behaviour cannot be readily observed, it appears realistic to assume that elected officials prefer to avoid adverse consequences for local industries. First, an influential body of literature in psychology and behavioural economics suggests that humans pay more attention to negative information (Rozin and Royzman, 2001), and tend to be averse to loss (Tversky and Kahneman, 1991). Public opinion has also been shown to respond disproportionately to negative economic news (Soroka, 2006). Second, practice shows that governments are reluctant to let industries significantly associated with regions disappear. For instance, both the Canadian and American governments provided financial assistance for their automotive industries during the recent economic crisis, which represent large employers with a symbolic attachment to regional economies. The Canadian federal government specifically developed a program in 2008 to support traditional industries affected by the crisis, focusing on sectors such as forestry and agriculture (Canada, 2008, 16). In fact, the use of public funds to support specific industries extends beyond economic hard times. A recent proceedings of the OECD's *Global Forum on Competition* estimated that public aid to industries represented 1% of the European Union's gross domestic product in 2008 (OECD, 2011*a*, 18), excluding crisis-related stimulus packages. Although subsidies may serve strategic goals other than preventing the depletion of specific sectors of the economy, it is probably fair to say that governments care a great deal about the fate of national industries when making policy decisions. Accordingly, I expect that when managing immigration policies, governments prefer to keep the stability in the industry mix, rather than to induce changes that would be detrimental to a sector.

To represent this problem, the objective function of the incumbent government can be expressed as a weighted sum of the quadratic distance from the ideal points of each industry:

$$\max_{y} U = -(1-y)^2 X - y^2 Z. \tag{4.7}$$

Put another way, this utility function means that the government seeks to minimize the loss that the industry X would incur from high proportions of skilled migrants, and the loss that industry Z would incur from high proportions of unskilled migrants. The solution to this problem, denoted y^*, is proportional to the share of the X industry in the whole economy:

$$y^* = \frac{X}{X+Z}. \tag{4.8}$$

The comparative static of interest suggests that the share of unskilled immigrants increases in the intensity of the low-technology industry.

In the section that follows, I implement a test of the relationship between the mix of industries classifiable in the low-technology sector and unskilled immigration in Canada. An obvious difficulty arises due to the simultaneity of the relation between industry mix and immigration. Indeed, the reason why a government would adjust the selection of immigrants in response to industry mix is precisely because of rational expectations regarding the impact of immigration on those industries. Thus, I devote particular attention to endogeneity issues before making inferences.

4.2 Data and Methodology

In order to implement an empirical test of the argument, I make use of data on immigration and industry mix in Canadian provinces between 2001 and 2010. Before presenting the empirical research design, however, it may prove useful to introduce background notions on immigration policies in Canada.

Permanent residents admitted to Canada fall into three main categories: refugees, family reunification immigrants, and economic immigrants (under Section 12 of the current *Immigration and Refugee Protection Act* (IRPA)). Since 1967, a point system was established to select immigrants from the latter category according to criteria deemed desirable, such as age, work experience, educational attainment, the existence of a labour market demand for the immigrant's profession, or the intended place of residence (Labelle, 1988; Reitz, 2004; Beach, Green, and Worswick, 2011). Thus, the management of economic immigration can be readily adapted to very specific requirements. Moreover, the gap between the number of applicants and the number of admissions combined with the existence of an important backlog means that governments dispose of latitude when selecting permanent residents.[2] In other words, the skill composition of immigration is unlikely to be merely driven by self-selection mechanisms.

Under Section 95 of the *Constitution Act* of 1867, the management of immigration in Canada is a responsibility shared between the federal and provincial governments (Canada, 2013*h*). However, the federal government keeps the upper hand in the case where the policies of a province would conflict with existing federal laws, Section 95 stating that provinces can exert authority "as long and as far only as it is not repugnant to any Act of the Parliament of Canada" (Canada, 2013*h*, Section 95). Since the issuance of permanent

[2]For instance, in 2010 and 2011, the total backlog was around one million applications for permanent resident visas (CIC, 2013).

resident visas is managed by federal agencies, it is probably fair to say that, in practice, immigration has been primarily under the control of the federal government.

Albeit the central role of the federal government, provinces have a say in the political management of immigration, and their influence has increased over time. When setting yearly immigration quotas, the federal government must meet with the provinces (under Section 10.2 of the IRPA), leaving the possibility to reach agreements with respect to the quantity and composition of the immigrants admitted to each province (CIC, 2011*b*, 2). But the involvement of provinces in the selection of immigrants has recently become more concrete. First, since the 1960s, the province of Quebec was granted an exceptional status allowing it to pre-select all of the immigrants intending to reside in the province (Labelle, 1988; Reitz, 2004). Although this agreement was driven primarily by language issues, Quebec also uses its own point system, which implies that the province's government may select immigrants that fit the specific needs of its local industries. Second, the other provinces were provided with a similar opportunity under the form of the *Provincial Nominee Program* (PNP) established in 1998 (CIC, 2011*b*). Under the PNP, provinces are allowed to select their permanent residents from the economic category. An officially stated goal of the PNP is precisely to "increase the economic benefits of immigration to [provinces], based on their economic priorities and labour market conditions [...]" (CIC, 2011*b*, 1). Even though the federal government remains the central authority issuing legal visas to foreigners, the selection process has been increasingly shaped by the provinces, making regional concerns a key aspect of the decision-making process.

4.2.1 A Simultaneous Equations Approach

The main feature of the theoretical model discussed in the previous section is the simultaneity of the relationship between industry mix and the policy response. Indeed, my main argument is that policy-makers will adjust the selection of immigrants as a function of local industries. But the motivation behind this decision is the expected impact of immigration flows on national industries. In other words, the causal relationship linking the intensity of low-technology industries to unskilled immigration is likely to work in both directions.

Letting $x = \frac{X}{X+Z}$ denote the intensity of the low-technology sector, the relationship of interest can be expressed as a system of empirical equations, including intercepts and disturbance terms:[3]

$$y = \alpha + \beta x + u, \tag{4.9}$$

$$x = \eta + \theta y + \epsilon. \tag{4.10}$$

When attempting to estimate (4.9) with classical regression techniques such as ordinary least squares (OLS), a common problem of endogeneity arises. Indeed, any innovation in the residuals u affects the value of unskilled immigration y, as shown in (4.9). This shock in y will cause a change in the value of x, due to the relationship depicted in (4.10). Thus, the residuals u are, by definition, correlated with the right-hand side variable x, violating a basic assumption of OLS regression.

In this section, I make use of an instrumental variable/two-stage least squares (2SLS) approach to estimate the system introduced in (4.9) and (4.10), and the parameter of interest β. The objective is to find valid *instruments* for the endogenous regressors when estimating equations (4.9) and (4.10). The ideal instruments for the right-hand side variable x in (4.9) should have two properties: 1) they need to be good predictors of x, and importantly 2) they must explain a part of the variation in x that is not responsive to

[3]For simplicity of presentation, I do not use subscripts for units and time periods in this section.

changes in y (see Kennedy, 2008; Angrist and Pischke, 2008). Put another way, the instruments must be variables that affect y only through their indirect effect on x. In this case, my goal is to avoid relying upon factors of production such as labour measures, which are themselves problematic variables.

I consider two variables that meet the requirements to serve as instruments for the low-technology sector variable x in (4.9): provincial gross expenditures in research and development (GERD) from non-business sectors, and the provincial land area. Non-business GERD should reasonably affect the intensity of low-technology industries in a given province. Moreover, since those expenditures come from a variety of sources (different levels of government, non-profit research organizations or universities), they are unlikely to be a direct determinant of the selection of immigrants. As for the land area of provinces, it represents a strictly exogenous variable whose values have been determined in part by nature, and in part by political decisions made decades ago. Moreover, land represents a traditional factor of production, which should realistically have had an influence on the specialization of production over time. In particular, a larger land area should be associated with a greater variety of resources, and a potential for the diversification of industries in a province. In the rest of this paper, I refer to those two instruments as *GERD* and *Land Area*, respectively.

Similarly, I consider instruments to identify the other side of the relationship in (4.10). This time, I make use of the shares of immigrants in the refugee and family reunification categories, by province. I claim that those represent ideal instruments for the intensity of unskilled immigration y. Indeed, by any stretch of the imagination, permanent residents cannot affect the mix of industries simply because of the “essence” of being a refugee or a family class immigrant. Rather, the proportions in those two groups are likely to affect the industry mix only to the extent that their aggregate skill levels differ from that of other immigrants. In other words, I expect the shares of refugees and family immigrants to affect x only through their indirect effect on y, the intensity of unskilled immigration, making them appropriate instruments. I refer to those two instruments using the labels *Refugees* and *Family*.

The system of equations introduced in (4.9) and (4.10) can be respecified by including the above-mentioned instruments as predictors in the appropriate equations:

$$y = \alpha + \beta_1 x + \beta_2 \text{Refugees} + \beta_3 \text{Family} + u, \tag{4.11}$$

$$x = \eta + \theta_1 y + \theta_2 \text{GERD} + \theta_3 \text{Land Area} + \epsilon. \tag{4.12}$$

This system of simultaneous equations is (over-)identified, and can be estimated empirically using 2SLS. One way to represent the 2SLS estimator consists of depicting the first-stage (or reduced form) equations used to predict values of the endogenous regressors. In this case, the reduced form equations correspond to

$$\hat{x} = \pi_{11} + \pi_{12} \text{GERD} + \pi_{13} \text{Land Area} + \pi_{14} \text{Refugees} + \pi_{15} \text{Family}, \tag{4.13}$$

$$\hat{y} = \pi_{21} + \pi_{22} \text{GERD} + \pi_{23} \text{Land Area} + \pi_{24} \text{Refugees} + \pi_{25} \text{Family}. \tag{4.14}$$

Notice that *all* of the system's instruments *must* enter each of the reduced form equations when creating instrumented variables. The predicted values $\hat{x}$ and $\hat{y}$ obtained from (4.13) and (4.14) are now uncorrelated with the error terms of the structural form equations, provided that the instruments have all the required properties. This means that with valid instruments, 2SLS estimates are robust not only to simultaneity (reverse causation), but also to endogeneity problems more generally, for instance omitted variable biases (see Kennedy, 2008, Ch. 9). Moreover, notice that the system is over-identified: there are more instruments than required to estimate the structural equations. This is a desirable property, allowing the use of over-identification restriction tests in order to assess the validity of instruments.

In the empirical analysis that follows, I first estimate this model using a pooled 2SLS estimator. Semykina and Wooldridge (2008, 8-10) show that this estimator is consistent for panel data when a minimal number of assumptions are met, such as the absence of correlation between instruments and the residuals. Notice that since one of the variables does not vary over time (Land Area), implementing a fixed effects 2SLS estimator becomes impossible. However, I also show that the key results hold when using a generalized two-stage least squares (G2SLS) estimator (or random effects 2SLS), and a dynamic panel data estimator based on the generalized method of moments (GMM).

4.2.2 The Data

The endogenous variable of interest is the share of unskilled permanent immigrants, labelled y earlier. I define unskilled immigrants as those individuals without university education. I make use of the *Digital Library* provided by *Citizenship and Immigration Canada* (CIC) to retrieve the total entries of permanent residents aged 15 years and over, broken down by educational attainment and by province (CIC, 2011*a*). The variable called *Unskilled Immigration* in the following analysis represents the share of permanent residents aged 15 and over classified as unskilled. I consider permanent residents in general (rather than economic migrants specifically) for two main reasons: first, the breakdown of immigrants by category and level of education is not made available for all provinces by CIC, and second, estimating the relationship from immigration policies toward the industry mix is more accurate when considering all sources of admission. Moreover, notice that the specification in (4.11) already filters away the variation in y caused by changes in the family and refugee classes, leaving only the variation within classes. As mentioned before, the data cover the period ranging from 2001 to 2010, which amounts to 100 observations, excluding territories. The mean of the Unskilled Immigration variable, across the 10 provinces during the whole time-period, equals 71%. Put the other way around, slightly less than 30% of all new entries of permanent residents aged 15 and over are individuals who declare disposing of a completed university degree.

The second key endogenous variable is the intensity of industries comprised in the low-technology sector, labelled x in the previous section. This concept is meant to measure the importance of traditional industries in each provincial economy. To transform the theoretical concept into an indicator, I first consider the breakdown of industries based on the *North-American Industry Classification System* (NAICS). I retain 32 industries for which all the required data are available. The list of those industries is reported in Table 4.1. Excluded from this list are the sectors of health care, education, public administration, and miscellaneous services. Health care and education are for a large part (if not the most part) publicly managed in Canada. Like public administration, those sectors do not fit into the conceptual definition introduced in the theoretical section. As for the category comprising miscellaneous service industries (a residual category for all service industries not listed in Table 4.1), there were no consistent data available to include it in the creation of the variable. Otherwise, the list is exhaustive and comprises all industries of the Canadian economy.

The next step consists of ranking those industries according to their level of technological sophistication. To do so, I rely upon an empirical technique. I use data on business expenditures in research and development (BERD) by industry, in Canada as a whole, made available from Statistics Canada (Canada, 2013*f*). I then compute the ratio of BERD to industry gross domestic product, averaged across the sample time-period.[4]

[4]I computed the gross domestic product by industry at the national level using aggregated data from provinces (Canada, 2013*g*).

Table 4.1: Classification of Industries by Level of Technology

Industry	NAICS	BERD (% of Output)	Technology Ranking Binomial	Technology Ranking Trinomial
Primary Sector and Construction				
Agriculture, Forestry, Fishing and Hunting	11	0.39	Low	Low
Mining and Oil and Gas Extraction	21	0.94	Low	Mid
Utilities	22	0.68	Low	Low
Construction	23	0.11	Low	Low
Manufacturing				
Food	311	0.77	Low	Low
Beverage and Tobacco Product	312	0.73	Low	Low
Textile and Clothing	313-316	1.04	Low	Mid
Wood Product	321	0.77	Low	Low
Paper	322	2.92	High	Mid
Printing and Related Activities	323	0.60	Low	Low
Petroleum and Coal Products	324	6.66	High	High
Pharmaceutical	3254	22.54	High	High
Chemicals (except Pharmaceutical)	325	2.35	High	Mid
Plastic Product	3261	1.67	High	Mid
Rubber Product	3262	2.20	High	Mid
Non-Metallic Mineral Product	327	1.03	Low	Mid
Primary and Fabricated Metal Product	331-332	1.68	High	Mid
Machinery	333	3.84	High	High
Computers	3341	18.09	High	High
Electronical (except Computers)	334	44.08	High	High
Electrical Equipment	335	6.54	High	High
Motor Vehicle and Parts	3361-3363	2.24	High	Mid
Aerospace Product and Parts	3364	13.66	High	High
All Other Transport	3365-3369	15.27	High	High
Furniture and Related Product	337	0.63	Low	Low
Miscellaneous Manufacturing	339	0.05	Low	Low
Services				
Wholesale Trade	41	1.32	Low	Mid
Retail Trade	44-45	0.06	Low	Low
Transportation and Warehousing	48-49	0.10	Low	Low
Information and Cultural Industries	51	2.32	High	Mid
Finance	52	0.12	Low	Low
Professional, Scientific and Technical Services	54	4.79	High	High

The table lists the principal industries of the Canadian economy, along with the corresponding North American Industry Classification System (NAICS) codes, and the average intramural business expenditures in R&D as a ratio of each industry's output in Canada as a whole, between 2000 and 2010. The last columns present two classifications of industries based on the technology level.

This gives a detailed measure of the level of technology in each of the 32 industries, the values of which are reported in the second column of Table 4.1.

I consider two different criteria to classify industries composing the low-technology sector. Those criteria are based on the percentiles of the BERD variable. The third column of Table 4.1 shows a first classification of the 32 industries depending on whether they are located above or below the 50th percentile (i.e. the median). Alternatively, the fourth column shows a trinomial classification based on the $33\frac{1}{3}$th and $66\frac{2}{3}$th percentiles. In the latter, each industry is classified as either low-, mid- or high-technology. As can be observed from the table, the classification appears relevant substantively, given the nature of each industry. High-technology industries comprise the most sophisticated sub-sectors of manufacturing, for instance computers, electronics, aeronautics, or pharmaceutical industries. The *Professional, Scientific and Technical Services* industry comprises engineering and scientific consulting firms, and is realistically classified in the high-technology category. On the other hand, the low-technology category comprises, for both classifications, various traditional industries such as agriculture, food manufacturing, textile manufacturing, and trade services.

Based on those classifications, I create four variables measuring the intensity of the low-technology sector. The reliance upon four measures is purposely meant to ensure that the empirical results are not merely driven by the choice of a particular classification. The first variable is the share of provincial gross domestic product in low-technology industries, based on the binomial, 50th percentile classification. Output data at basic prices, by industry and by province, come from Statistics Canada (Canada, 2013*g*).[5] The

[5]Some provincial data points for small industries are not disclosed by Statistics Canada, since those values would allow the identification of specific firms. In those cases, I have removed the output of those industries from both the numerator and the denominator when computing the share of output in the low-technology sector (in other words, the missing elements were set to zero). Using this method, there were no missing data in the final data set.

second variable is the share of provincial output in both the low- and mid-technology industries, based on the trinomial classification. Thus, those two measures represent a narrow and a broad definition of the low-technology sector, respectively. Finally, I create two additional variables by computing the previous measures after excluding primary sector and construction industries. The reason behind those additional measures is to make sure that the estimated relationships are not only driven by the specific sectors of energy and natural resources, which play an important role in the economy of some provinces. For the sake of simplicity, I refer to the four variables as *Low-Tech Sector* below, although the tables will specify which definition is used.

As for the instruments introduced above, they are measured as follows. The GERD variable represents non-business gross expenditures in R&D (GERD), by province, as a ratio of total provincial output. The data come once again from Statistics Canada (Canada, 2013*e*). Non-business GERD comprise the total expenditures in R&D by all types of funders, with the exception of the business sector, since the latter is used for the classification of industries. The idea is to capture the variation in the Low-Tech Sector variables that is orthogonal to the residuals of the structural form equations, hence exogenous to unskilled immigration. Next, the Land Area of provinces is measured in square meters, using the data provided in Canada (2005*b*). Finally, the shares of all immigrants in the refugee and family reunification classes, by province, are taken from the CIC Digital Library mentioned earlier.

Table 4.2 reports descriptive statistics for the main variables of the system of equations introduced in (4.11) and (4.12), broken down by province. The mean values are expressed as percentages. To ease the legibility of this table, I report descriptive statistics only for the first definition of the Low-Tech Sector variable (the one based on the binomial classification and including primary-level industries). As can be seen, there is a fair amount of variation in the means of each of the series across provinces. In particular, Newfoundland and Saskatchewan have the highest average shares of low-technology industries among the 10 provinces, whereas Quebec and Ontario appear to rely most heavily on high-technology industries.

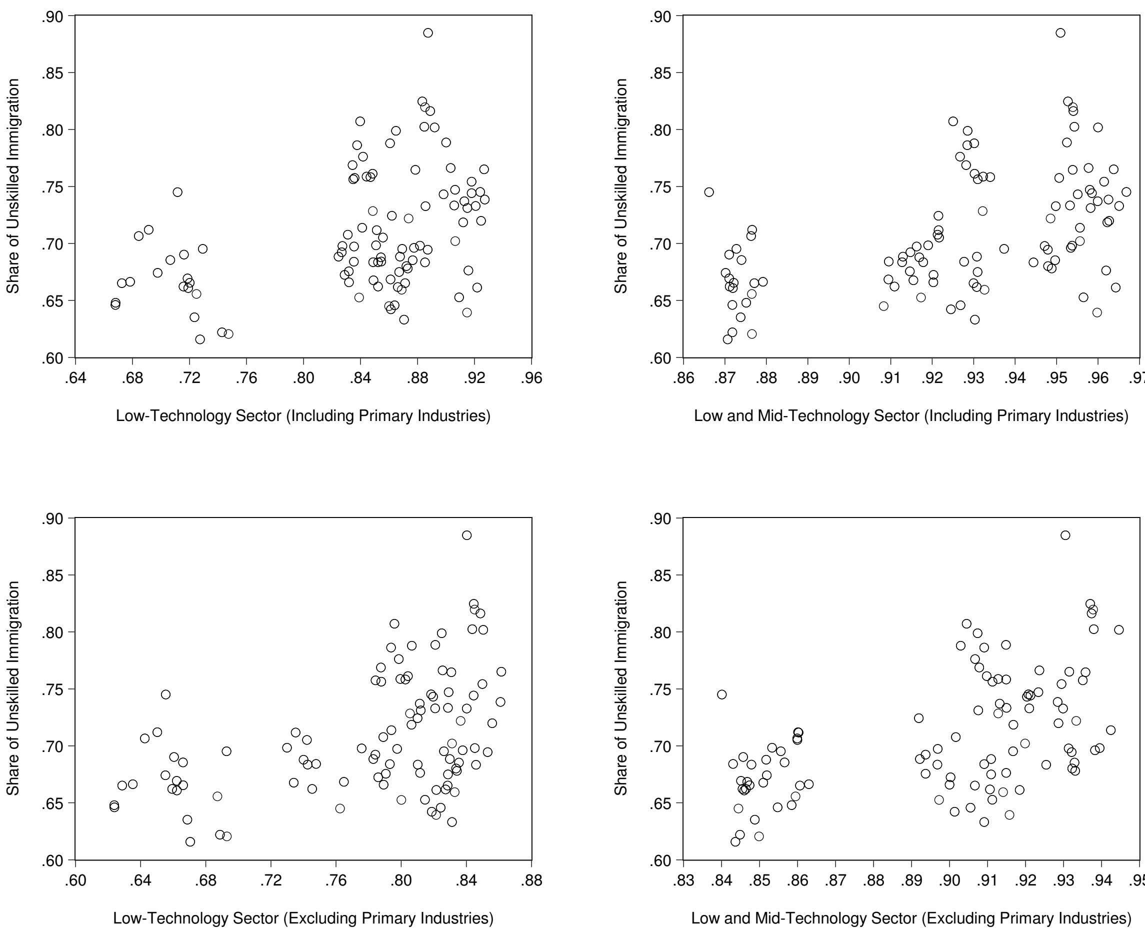
Table 4.2: Descriptive Statistics

Province	Unskilled Immigration	Low-Tech Sector	Public GERD	Refugee Class Share	Family Class Share
Newfoundland	70.84%	91.45%	0.65%	29.29%	19.32%
	(4.83)	(0.69)	(0.06)	(5.83)	(2.56)
Prince Edward Island	79.60	88.08	0.82	18.58	12.33
	(4.71)	(1.09)	(0.15)	(15.8)	(8.85)
Nova Scotia	66.51	86.90	0.96	10.51	22.85
	(2.07)	(0.64)	(0.03)	(3.41)	(4.31)
New Brunswick	70.24	86.45	0.50	15.59	19.83
	(2.37)	(2.13)	(0.05)	(7.7)	(6.75)
Quebec	65.88	72.41	0.86	14.09	19.69
	(3.92)	(1.19)	(0.05)	(3.84)	(1.4)
Ontario	67.56	69.20	0.80	12.39	28.73
	(2.36)	(2.23)	(0.05)	(2.23)	(2.73)
Manitoba	77.02	84.41	0.69	14.20	14.52
	(2.3)	(0.9)	(0.03)	(6.17)	(4.43)
Saskatchewan	74.15	91.34	0.69	22.73	17.72
	(1.96)	(1.07)	(0.08)	(10.5)	(6.13)
Alberta	68.15	85.41	0.53	10.57	30.12
	(2.07)	(0.39)	(0.02)	(2.24)	(3.16)
British Columbia	68.21	83.33	0.50	4.88	30.02
	(1.60)	(0.69)	(0.04)	(1.00)	(2.94)

The table reports the means of five main variables for the time-period 2001-2010, by province, expressed in percentages, along with standard deviations in parentheses. The Low-Tech Sector variable is based on the binomial classification and includes primary level industries.

Finally, Figure 4.1 shows scatterplots of the bivariate relationship between the Unskilled Immigration and Low-Tech Sector series, using each of the four alternative definitions of the low-technology sector. As clearly comes out from all of the sub-figures, there seems to be a positive relationship between the two series. Although the patterns observed in those scatterplots appear consistent with the main argument of this paper, the key issue is to distinguish between each side of the relationship. For the reasons emphasized earlier, Figure 4.1 may give a misleading picture of the true relationship going from the intensity of low-technology industries toward unskilled immigration.

Figure 4.1: Unskilled Immigration and the Intensity of Low-Technology Sectors in Canadian Provinces (2001-2010)



4.2.3 Unit Root Tests

As a preliminary step to empirical analysis, I test each of the main variables for stationarity. Non-stationary variables would require special treatment to ensure consistent empirical estimates (Granger and Newbold, 1974), and consequently unit root testing represents an essential step when using data comprising a time-series component.

I make use of the Levin-Lin-Chu panel unit root test of the null of non-stationarity (Levin, Lin, and Chu, 2002), performed on each of the five main time-varying series used in this study, including the four possible definitions of the Low-Tech Sector. In each case, I compute the test after including an intercept and a time trend. The Levin-Lin-Chu adjusted-t statistics are reported in Table 4.3, for 0, 1, and 2 lags, respectively. Since the sample time-period is limited to 10 years, it becomes irrelevant to consider larger lag lengths.

Table 4.3: Levin-Lin-Chu Panel Unit Root Tests

		Lags		
Type	Variable	0	1	2
Endogenous	Unskilled Immigration	–6.689***	–6.666***	–5.993***
	Low–Tech Sector (binomial)	–4.173***	–5.973***	–1.852*
	Low–Tech Sector (trinomial)	–5.563***	–7.499***	–7.882***
	Low–Tech Sector (binomial, w/o primary)	–4.589***	–5.315***	–1.309
	Low–Tech Sector (trinomial, w/o primary)	–6.228***	–7.542***	–7.964***
Instruments	Public GERD (% of Output)	–5.266***	–6.272***	–3.770***
	Refugee Class	–7.013***	–4.235***	–9.643***
	Family Class	–4.812***	–4.348***	–7.005***

The table reports adjusted t^* statistics of Levin-Lin-Chu tests of the null hypothesis that panels contain unit roots, along with significance levels. All tests are computed using the natural logarithms of the variables, along with intercepts and time trends. Significant statistics indicate that the variables are trend-stationary.
***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$.

As can be observed from Table 4.3, for mostly all cases considered, the null hypothesis of a unit root is rejected at the $p < 0.001$ significance level. The only exception is the Low-

Techn Sector series computed with the binomial codification and excluding the primary sector. In this case, the null cannot be rejected with confidence when 2 lags are included in the underlying augmented Dickey-Fuller regression. However, given the unambiguous verdicts for all other series, I will treat the main variables as trend-stationary in the empirical analysis that follows. In short, unit root processes are not a major concern in this study.

4.3 Empirical Results

Table 4.4 reports the results of pooled cross-sectional 2SLS estimates for the Unskilled Immigration equation, using each of the four definitions of the Low-Tech Sector variable. The bottom part of the table presents the reduced form (or first-stage) estimates. The upper part shows the structural (or second-stage) estimates, along with heteroskedasticity and autocorrelation consistent standard errors in parentheses. Notice that all variables are expressed in natural logarithms, so that estimates are comparable in size and can be interpreted as elasticities, i.e. as the percentage response in the dependent variable for a 1% increase in the corresponding right-hand side variable.

The first column of Table 4.4 presents the results using the first variant of the Low-Tech Sector measure, based on the binomial classification and including primary-level industries. Focusing on the first-stage estimates, both the excluded instruments GERD and Land Area are significantly associated with the share of industries in the low-technology sector, at the $p < 0.001$ level. This is a required property of the model, to ensure reliable structural estimates. The estimate for GERD has an intuitive negative sign: the value of –0.17 means that a 1% increase in non-business GERD leads to an estimated 0.17% decrease in the share of industries in the low-technology sector (or equivalently, to a 0.17% increase in the share of high-technology industries), all else equal. To further assess the adequacy

Table 4.4: 2SLS Estimates of the Unskilled Immigration Equation

Industry Sample:	With Primary-Level		W/O Primary-Level	
Technology Definition:	Low	Low-Mid	Low	Low-Mid
Structural Estimates				
Log Low–Tech Sector	0.361**	0.911**	0.316*	0.834*
	(0.138)	(0.344)	(0.131)	(0.359)
Log Refugees	0.011	0.008	0.019	0.015
	(0.011)	(0.011)	(0.010)	(0.010)
Log Family	–0.084***	–0.077***	–0.082***	–0.071***
	(0.013)	(0.015)	(0.014)	(0.019)
Time Trend	–0.012***	–0.011***	–0.011***	–0.009**
	(0.003)	(0.003)	(0.003)	(0.003)
Intercept	22.715***	20.905***	21.101***	18.477**
	(6.344)	(6.065)	(5.689)	(5.857)
R^2	0.496	0.522	0.535	0.523
Hansen–J	0.396	0.352	1.226	1.367
p–value (Hansen)	0.529	0.553	0.268	0.242
First–Stage Estimates				
Log GERD	–0.183***	–0.075***	–0.157***	–0.060***
	(0.045)	(0.014)	(0.042)	(0.014)
Log Land Area	–0.024***	–0.009***	–0.030***	–0.012***
	(0.007)	(0.002)	(0.006)	(0.002)
Log Refugees	0.048**	0.023***	0.029	0.015**
	(0.015)	(0.005)	(0.016)	(0.005)
Log Family	–0.041	–0.025***	–0.039	–0.028**
	(0.022)	(0.007)	(0.022)	(0.008)
Time Trend	0.005	0.001	0.004	–0.000
	(0.004)	(0.001)	(0.004)	(0.001)
Intercept	–11.485	–2.516	–8.375	–0.030
	(7.688)	(2.323)	(7.658)	(2.801)
R^2	0.460	0.620	0.490	0.576
Angrist–Pischke F–Test	12.53***	20.43***	17.55***	23.76***
N	100	100	100	100

The table reports pooled cross-sectional 2SLS estimates, along with Newey-West standard errors computed using a two-lag bandwidth in parentheses. The dependent variable in the structural equations is the log of Unskilled Immigration.
The column headers indicate which definition was used to compute the Low-Tech Sector variable. The first column reports results using the binomial classification, whereas the second column is based on a grouping of the low- and mid-technology industries using the trinomial classification (see Table 4.1). The third and fourth columns replicate the same measures after excluding the primary sector.
***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$.

of the instruments, I report the Angrist-Pischke multivariate F-Test at the bottom of the table (Angrist and Pischke, 2008): a significant statistic rejects the null hypothesis of weak instruments, as is the case in this model.

Turning to the structural estimates in the upper part of Table 4.4, and still focusing on the first column, the coefficient of interest for the instrumented Low-Tech Sector variable appears significantly associated with the share of unskilled immigration in the recipient province. The estimated elasticity is approximately 0.36: an exogenous shock increasing the intensity of low-technology industries by 1% induces an estimated 0.36% increase in the share of unskilled immigrants. This result is consistent with the theoretical idea that governments adjust the levels of unskilled immigration according to the provincial industry mix, although the value lower than one suggests that this adjustment is short of a one-for-one proportional response. Notice that the coefficient of interest can be interpreted the other way around: a 1% exogenous increase in the intensity of *high*-technology industries induces an estimated 0.36% increase in the share of *skilled* immigrants.

However, the magnitude of the effect depends on how one defines the low-technology sector. The second column of Table 4.4 reports estimates based on the broader definition of the low-technology sector (regrouping industries classified in both the low- and mid-technology categories). In this case, the estimated elasticity is closer to the value of one, suggesting that the skill composition of immigration responds proportionally to changes in the intensity of the low-technology sector, on a nearly one-for-one basis. Importantly, the first stage estimates for the excluded instruments remain statistically significant after changing the definition of the low-technology sector.

The last two columns of Table 4.4 replicate the same analysis, this time by excluding primary-level industries. Using either the narrow or broad definition of the Low-Tech Sector, the estimates are close in size to the ones found earlier. The structural estimates of interest remain within the bounds of the 95% significance level, and the elasticities are respectively of 0.32 and 0.83. Overall, the direction of the key comparative static appears robust to modifications in the definition of the low-technology sector.

An important statistical tool to evaluate whether the 2SLS approach effectively eliminates the correlation between the problematic right-hand side variables and the residuals is the Sargan-Hansen over-identification restriction test. The null hypothesis of this test is that all instruments are valid. The last rows of the upper panel of Table 4.4 report the Hansen-J statistics of this test, for all models, along with the p-values. Using either one of the four definitions of the low-technology sector, those statistics are well outside the conventional bounds of statistical significance (considering the value of 0.05 as a benchmark), confirming the adequacy of the chosen instruments.

As a next step, Table 4.5 reports the results for the other side of the relationship. This time, the proportions of immigrants in the refugee and family categories are used as excluded instruments for the share of unskilled immigration. The results are presented in a similar fashion, except that the estimates of the first-stage regression are actually the same for each of the Low-Tech Sector variables. Thus, they are only reported once.

Starting with the first-stage estimates in the bottom part of Table 4.5, notice that both the Refugees and Family variables are significantly related to Unskilled Immigration. Again, this is a desirable property to obtain consistent structural coefficients. The Angrist-Pischke multivariate test is once again statistically significant at the $p < 0.001$ level. The Sargan-Hansen over-identification tests, reported in the upper part of the table, are non-significant, for all four definitions of the low-technology sector. However, the null is close to be rejected in the first two columns, when including the primary sector in the construction of the Low-Tech Sector variable. This suggests that results for the industry equation may be more reliable when excluding the primary sector. Even so, the structural estimates

Table 4.5: 2SLS Estimates of the Low-Tech Sector Equation

Industry Sample:	With Primary-Level		W/O Primary-Level	
Technology Definition:	Low	Low-Mid	Low	Low-Mid
Structural Estimates				
Log Unskilled Immigration	0.537*	0.298***	0.436*	0.293***
	(0.241)	(0.089)	(0.221)	(0.083)
Log GERD	–0.136***	–0.049***	–0.121***	–0.036*
	(0.034)	(0.012)	(0.034)	(0.016)
Log Land Area	–0.019*	–0.007*	–0.027***	–0.009***
	(0.007)	(0.003)	(0.007)	(0.003)
Time Trend	0.006	0.002	0.006	0.002
	(0.004)	(0.001)	(0.003)	(0.001)
Intercept	–11.980	–3.946	–11.916	–3.597
	(7.366)	(2.705)	(6.809)	(2.640)
R^2	0.380	0.428	0.487	0.488
Hansen–J	3.201	3.778	1.034	1.130
p–value (Hansen)	0.074	0.052	0.309	0.288
First–Stage Estimates				
Log Refugees	0.030*			
	(0.012)			
Log Family	–0.107***			
	(0.016)			
Log GERD	–0.080**			
	(0.027)			
Log Land Area	–0.006			
	(0.005)			
Time Trend	–0.010**			
	(0.003)			
Intercept	19.112**			
	(5.830)			
R^2	0.560			
Angrist–Pischke F–Test	26.12***			
N	100			

The table reports pooled cross-sectional 2SLS estimates, along with Newey-West standard errors computed using a two-lag bandwidth in parentheses. The dependent variable in the structural equations is the log of Low-Tech Sector.
***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$.

happen to be very similar with or without the primary sector.

As can be seen, the structural estimates reported in Table 4.5 are positive and statistically significant at the 95% confidence level or above for all definitions of the Low-Tech Sector variable. For instance, the third column indicates that a 1% exogenous increase in the share of unskilled immigration is associated with a 0.44% increase in the intensity of low-technology industries. The size of this elasticity falls to approximately 0.3 when considering the broader definition based on the trinomial classification of industries.

Notice that the ordering of the size of elasticities is reversed compared to the results of Table 4.4 discussed earlier. This result is actually consistent with the proposed theory. The more traditional the pool of industries under consideration (or the narrower is the definition of the Low-Tech Sector variable), the more likely it is to rely intensively on unskilled labour and to benefit from unskilled immigration, as suggested by the elasticities in Table 4.5. When considering the policy side of the relationship (as presented in Table 4.4), the opposite ranking holds, which is also consistent with the theory. The broader is the measure of the low-technology sector, the larger is the political importance of that sector, and the more proportional is the response of policies to a shock in the intensity of that sector.

4.3.1 Robustness Tests

In order to assess the robustness of the main findings presented so far, I now turn my attention to alternative specifications of the models. To begin with, I consider a G2SLS estimation of the Unskilled Immigration equation presented earlier in Table 4.4, as well as specifications including additional control variables. Next, I report results obtained using a dynamic implementation of the original models, using GMM estimators.

The G2SLS model introduced in Balestra and Varadharajan-Krishnakumar (1987) allows the residuals of (4.11) to be decomposed as follows:

$$u = \mu_i + v_{i,t}, \tag{4.15}$$

where the subscripts i and t respectively indicate the province and the time-period, μ_i captures unobserved provincial effects, and $v_{i,t}$ represents idiosyncratic errors. The random effects model estimates the variances of μ_i and $v_{i,t}$, which are then used to transform the original data. In what follows, I make use of the Baltagi and Chang (2000) estimator of those variance components.

The first two columns of Table 4.6 replicate the first two models of Table 4.4, using the G2SLS approach. As can be seen, the structural coefficients of interest are close to the ones obtained earlier, although slightly larger in size. For instance, the estimated coefficient for the instrumented Low-Tech Sector in column 1 is now 0.44, compared to the value of 0.36 obtained using pooled 2SLS. Notice that the Sargan-Hansen tests once again suggest that the instruments are appropriate. Also, the instruments remain significant predictors of the Low-Tech Sector variables in the first-stage.

To produce the results in the last two columns of Table 4.6, I include additional control variables in the model. The Oil Production variable is a dummy indicating whether the province is an oil producer. It equals one for the three major oil-producing Canadian provinces (namely Alberta, Saskatchewan, and Newfoundland and Labrador), and zero otherwise. The Unemployment variable measures the rate of unemployment in manufacturing industries by province, lagged one period (Canada, 2013*d*). Finally, I include the share of total working-age population without a university degree in each province (Canada, 2013*g*), lagged one period, to account for the initial conditions in the skill composition of the labour force. This variable is named Unskilled Labour in the results table.

Table 4.6: G2SLS Estimates of the Unskilled Immigration Equation

Industry Sample:	With Primary-Level			
Technology Definition:	Low	Low-Mid	Low	Low-Mid
Structural Estimates				
Log Low–Tech Sector	0.443*	1.105*	0.741**	2.167***
	(0.175)	(0.473)	(0.225)	(0.547)
Log Refugees	0.025	0.026	0.071***	0.065***
	(0.014)	(0.016)	(0.015)	(0.014)
Log Family	–0.068***	–0.058**	–0.127***	–0.117***
	(0.017)	(0.019)	(0.020)	(0.018)
Oil Production			–0.079**	–0.048*
			(0.027)	(0.022)
Log Unemployment $(t-1)$			–0.043**	–0.031*
			(0.015)	(0.015)
Log Unskilled Labour $(t-1)$			–1.285*	–1.767**
			(0.576)	(0.630)
Time Trend	–0.009***	–0.007***	–0.015***	–0.016***
	(0.002)	(0.002)	(0.004)	(0.004)
Intercept	17.647***	14.038***	30.276***	31.945***
	(4.097)	(3.769)	(7.637)	(7.282)
R^2	0.460	0.478	0.671	0.667
Hansen–J	0.359	0.115	0.767	0.010
p–value (Hansen)	0.549	0.734	0.381	0.919
First–Stage Estimates (Excluded Instruments Only)				
Log GERD	–0.133***	–0.009***	–0.025*	–0.008***
	(0.028)	(0.002)	(0.005)	(0.001)
Log Land Area	–0.023***	–0.056***	–0.060***	–0.034***
	(0.005)	(0.009)	(0.024)	(0.008)
		[...]		
N	100	100	100	100

The table reports the results of G2SLS regressions using Baltagi-Chang consistent estimators of the variance components, along with standard errors in parentheses. To ease legibility, only the first-stage estimates for excluded instruments are reported. The dependent variable in the structural equations is the log of Unskilled Immigration.

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$.

After including those additional control variables, the estimates of interest for the intensity of the low-technology sector are considerably magnified, close to twice the size of those reported in the first two columns. The new specification has potential drawbacks, however, and the results should be interpreted with caution. If the additional control variables are not strictly exogenous, as may be the case for Unemployment or Unskilled Labour, the new models may actually introduce an endogeneity bias that I sought to avoid in the first place. Here, my goal is primarily to show that the signs of the structural estimates remain consistent after including control variables that may be substantively relevant.

Finally, I replicate the results of Table 4.4 after considering the dynamics in the system, using GMM estimators for panel data. The initial migration equation in (4.11) can be readily expressed in dynamic terms:

$$y_{i,t} = \alpha y_{i,t-1} + \beta_1 x_{i,t} + \beta_2 x_{i,t-1} + \beta_3 \text{Refugees}_{i,t} + \beta_4 \text{Family}_{i,t} + u_{i,t}, \tag{4.16}$$
$$u_{i,t} = \mu_i + v_{i,t},$$

where the disturbance terms are again decomposed into individual effects and i.i.d. errors. Arellano and Bover (1995) and Blundell and Bond (1998) proposed a system GMM estimator making use of lagged values in levels and first differences of the endogenous right-hand side variables to create GMM-instruments. Those instruments are then used to impose moment conditions on both the level equation and a first difference transformation of that equation. The GMM estimator was initially intended to deal with the bias resulting from the inclusion of a lagged dependent variable, which is by construction correlated with the individual effects in the disturbances (Arellano and Bond, 1991). However, the GMM approach is flexible enough to deal with other endogenous regressors, in this case $x_{i,t}$, the

Low-Tech Sector variable. The same set of instruments used in the 2SLS models can be incorporated in the model, in addition to GMM-type instruments.

The GMM approach has important benefits, since it allows to model the dynamics and to distinguish between short-run and long-run effects, to deal with endogenous covariates, and to account for unobserved individual effects in panel data. For instance, the instantaneous effect of a shock in the Low-Tech Sector variable is captured by β_1 in (4.16), whereas the long-run effect corresponds to $\frac{\beta_1+\beta_2}{1-\alpha}$. The only drawback with this approach is that the number of GMM-type instruments increases rapidly with the time dimension and the problematic regressors. The data set used in this paper, which is reduced to 9 time periods with the inclusion of lagged variables, implies the use of 28 GMM-type instruments for each endogenous regressor in the difference equation only, for a total of 56 (again, the two problematic regressors in (4.16) are $y_{i,t-1}$ and $x_{i,t}$). Adding GMM-type instruments in the level equation would increase the instrument count close to the number of observations, weakening the Sargan over-identification test. To limit the number of instruments, I consider a system GMM estimator in which only standard instruments (i.e. the set of variables used as instruments in the 2SLS approach) are considered in the level equation, whereas both the GMM and the standard instruments are included in the difference equation.

Table 4.7 shows the results obtained using this GMM estimator, replicating each of the four columns of Table 4.4. Focusing on the first column, the short-run elasticity of Unskilled Immigration with respect to the Low-Tech Sector variable corresponds to 0.63. The estimate is statistically significant at the $p < 0.01$ level, using standard errors robust to arbitrary heteroskedasticity and autocorrelation. This means that a 1% shock in the Low-Tech Sector variable induces a 0.63% increase in the share of unskilled immigration during the first year. The estimated effect in the second period corresponds to –0.14

(computed as $\alpha\beta_1 + \beta_2$, or 0.45(0.63) – 0.40), although statistically indistinguishable from zero. This value comprises the instantaneous effect carried over in the next period by the Unskilled Immigration variable itself (0.45 times 0.63), plus the direct short-run impact in the second period (–0.4). As for the long-run elasticity, it corresponds to $\frac{0.63-0.4}{1-0.45} = 0.42$, virtually identical to the estimate obtained using the G2SLS model (0.44), and close to the one initially found using the pooled 2SLS model (0.36). Put simply, the dynamic estimates suggest that the response of policies to a change in the intensity of the low-technology sector occurs mostly in the short-run, during the ensuing year.

The story is similar when considering the broader definition of the Low-Tech Sector variable in the second column of Table 4.7. Most of the impact of a change in the intensity of low-technology industries appears to occur in the short-run, and the estimated long-run elasticity ($\frac{1.45-0.67}{1-0.65} = 1.2$) is close in size to the values found earlier. The results based on the definitions excluding the primary sector are once again consistent with those obtained with the 2SLS estimator, as can be observed in the third and fourth columns. The non-significant values of the Sargan tests suggest that the instruments are valid (although recall that those tests are weakened by the large number of instruments, 65, relative to the number of observations). The full list of instruments in the difference and level equations is reported under Table 4.7.

In a nutshell, the additional tests presented in this subsection tend to reinforce the main conclusions previously drawn regarding the relationship between industry mix and unskilled immigration in Canada. A higher intensity of traditional industries in a province provokes the selection of higher proportions of unskilled immigrants, and this result appears robust to endogeneity and alternative specifications.

Table 4.7: GMM Estimates of the Unskilled Immigration Equation

Industry Sample:	With Primary-Level		W/O Primary-Level	
Technology Definition:	Low	Low-Mid	Low	Low-Mid
Log Unskilled Immigration $(t-1)$	0.447***	0.351***	0.459***	0.335*
	(0.082)	(0.093)	(0.098)	(0.140)
Log Low–Tech Sector	0.633**	1.453**	0.502**	1.191***
	(0.224)	(0.511)	(0.163)	(0.349)
Log Low–Tech Sector $(t-1)$	–0.410	–0.674	–0.302	–0.436
	(0.325)	(0.436)	(0.231)	(0.229)
Log Refugees	0.016	0.013	0.019**	0.017*
	(0.009)	(0.008)	(0.006)	(0.008)
Log Family	–0.033**	–0.028**	–0.032*	–0.027
	(0.012)	(0.011)	(0.013)	(0.017)
Time Trend	–0.000***	–0.000***	–0.000*	–0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
χ^2	2988.82***	3858.76***	2322.62***	2700.39***
No. of Instruments	65	65	65	65
Sargan Test	65.82	62.54	65.46	62.29
p–value (Sargan)	0.253	0.352	0.263	0.360
N	90	90	90	90

The table reports GMM estimates for dynamic panel data, along with standard errors robust to heteroskedasticity and autocorrelation in parentheses. The dependent variable is the log of Unskilled Immigration.

Instruments in the difference equation include the lags of Unskilled Immigration and Low-Tech Sector in levels, starting at $t-2$ on back (GMM-type instruments), as well as the variables GERD, Refugees, Family, and the time trend in first differences (standard instruments).

Instruments in the levels equation include GERD, Land Area, Refugees, Family, and the time trend (standard instruments).

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$.

4.3.2 Policy Implications

The findings of this paper lead to an important policy implication. The conclusions stressed in the previous section give credence to the idea that governments adjust the skill composition of immigration as a function of the needs of existing industries. As I show below, it follows that immigration policies tend to slow down the transition from traditional toward high-technology activities.

To illustrate this implication, let me first compare the current trends in the working-age population as a whole (i.e. including natives) against immigration trends in Canada. The compound annual growth rate of the skilled working-age population between 1990 and 2010 has been 4.5%, compared to 0.7% for the unskilled working-age population, based on data from the Canadian Labour Force Survey (LFS) estimates (Canada, 2013*c*).[6] In other words, skilled labour has increased more than six times faster than unskilled labour. Still based on LFS data, the share of the *annual change* in the working-age population composed of skilled workers was 58% on average between 2001 and 2010. That is, in a typical year of the 2000 decade, 42% of the net additional workers were unskilled, and 58% were skilled. Aside from net migration, those trends are driven by the combined arrival of younger cohorts from the native population and the departure of older cohorts, the former group having higher educational attainment rates than the latter. In contrast, as mentioned earlier, slightly less than 30% of working-age permanent residents admitted to Canada during the same period were skilled, and about 71% were unskilled. Thus, immigration flows tend to slow down the *change* in the skill composition of labour that would be induced by other demographic components alone.

Based on the argument proposed in this paper, those new cohorts of skilled workers

[6] The skilled working-age population refers to the population aged 15 years and over with a completed university degree.

in the population as a whole should benefit high-technology industries, at the expense of the more traditional ones. Nonetheless, the high-technology sector remains relatively small in Canada, which may explain the political incentives behind unskilled immigration. Depending on which of the four definitions proposed in this paper is used, high-technology industries represented between 7% and 20% of production in Canada during the period 2001-2010.[7] This means that the bulk of national production is still performed in lowly or moderately sophisticated industries. When governments adjust the skill composition of immigration to the existing industry mix, it follows that immigration tends to counterbalance the change induced by new cohorts of the recipient population. In other words, the findings of this paper suggest that immigration policies are committed to the status quo.

Whether this policy implication represents a problematic situation is of course a normative question. On one hand, the behaviour of governments may be interpreted as a fair response to the conflicting preferences of industries, taking into account the needs of traditional sectors already struggling with the waning intensity of unskilled labour. On the other hand, current policy decisions may lead to undesirable outcomes in terms of economic development, by tempering down the growth of industries playing a significant role in the process of technological change. An interesting avenue of future research would consist of assessing the consequences of this policy trade-off for economic outcomes.

[7] Of course, there are multiple ways to classify industries according to their level of technology, and industries considered as traditional today may eventually develop new technologies making them on par with the most advanced ones. Nevertheless, those figures are consistent with the shares of production in high-technology sectors computed by other statistical agencies. For instance, a recent Eurostat publication estimated the share of high-technology manufactures across the 27 countries of the European Union to be 12% in 2010 (Jaegers, Lipp-Lingua, and Amil, 2013).

4.4 Conclusion

The objective of this study was to find out whether governments manage the skill composition of immigration as a function of the existing regional industry mix. I argued that when selecting immigrants, governments solve a compromise between the preferences of industries, to avoid hurting sectors associated with the economy of regions. Thus, a stronger presence of traditional, low-technology industries leads a government to admit a larger proportion of unskilled immigrants. This argument was tested using panel data on Canadian provinces. To account for the simultaneity of the relationship between the composition of immigration and the industry mix, I made use of 2SLS estimators in which endogenous regressors are instrumented.

The empirical findings are generally consistent with the theoretical claims. Canadian provinces with larger shares of low-technology industries are more likely to receive larger proportions of unskilled immigrants. This relationship is robust to endogeneity, and to changes in the definition of the low-technology sector. The key results were replicated using GMM estimators taking into account unobserved provincial effects and the dynamics between the variables. I also found evidence supporting the other side of the relationship, from unskilled immigration toward the share of low-technology industries. Those results lead to an overlooked and counter-intuitive implication, namely that immigration can be viewed as a policy tool preventing the depletion of traditional industries, despite the presence of mechanisms aimed at the selection of skilled migrants. Indeed, the skill composition of immigration tends to match the needs of existing industries, in contrast to the change induced by natural increases in the labour force as a whole, which overwhelmingly benefit sectors relying upon skilled labour.

Chapter 5

Conclusion

This dissertation has set out to examine the determinants of immigration policies, and their consequences for recipient polities. The topic was initially motivated by the observed discrepancy between public opinion and actual immigration trends in Western countries. I have also argued that the economic narrative of Canadian politicians used to justify unpopular increases in immigration flows remains unsatisfactory. There is no clear theoretical support behind the idea that increasing the size of a polity's labour force using immigration induces only economic benefits. In fact, if there were unambiguous economic benefits to immigration, governments could easily open the door to even more foreigners, given the existence of wage incentives making developed countries an attractive destination (see Hatton and Williamson, 2005, Ch. 10-11). A more suitable explanation brought forth in the literature suggests that immigration induces particularistic benefits accruing to the corporate sector, which exerts influence on elected officials. As a result, policy outcomes represent a trade-off between the preferences of firms and of the public. This explanation, however, stumbles on the lack of quantitative evidence documenting the policy response to pressures from special interests. Moreover, existing works have rarely integrated factors such as the national industry mix and the skill composition of immigration into a single theoretical approach.

To address those issues, I proposed a theory of immigration policies explaining the preferences of national industries and the behaviour of elected governments with respect to immigration. Building upon international economics, in particular the Rybczynski theorem, I claimed that national industries are likely to form conflicting preferences over the skill composition of immigration. This stems from the expectation that industries relying intensively upon skilled labour are negatively affected by unskilled immigration, and conversely for industries intensive in unskilled labour. Moreover, and given a skill composition scheme that is acceptable to all industries, I claimed that the corporate sector is a proponent of expansive immigration policies, based on more common expectations stemming from neoclassical theory. Next, I argued that elected governments have incentives to take into account the preferences of national industries when managing immigration, since the corporate sector represents a powerful interest group able to influence re-election prospects, and since decisions detrimental to specific industries would spur negative reactions affecting their popularity. Consequently, I expected governments to increase immigration levels as a function of pressures from the corporate sector, and to adjust the skill composition of immigration as a function of the regional industry mix.

The empirical evidence gathered in the three core chapters brought support to several of the testable implications of this theory. Focusing on the case of Canada in Chapters 3 and 4, I have shown that governments are responsive to lobbying pressures from the corporate sector when managing the levels of (temporary) immigration, and that the skill composition of immigration adjusts to the existing provincial industry mix. Together, the findings suggest that immigration can be construed as a policy instrument used by governments to address the concerns of national industries. On the other hand, both Chapters 2 and 4 brought supportive evidence to the claim that immigration affects in turn the type of activities undertaken at the national level, confirming the relevance of the model used as a basis to explain the preferences of industries. The relationship between regional industry mix and the skill composition of immigration appears decidedly two-sided, as emphasized in Chapter 4 using a simultaneous equations approach. I have also shown that immigration policies tend to slow down the growth in the intensity of the private research sectors in OECD countries, due to the negative impact of unskilled labour on business R&D outlays.

The findings presented in the previous chapters cannot be claimed to exhaust all possible discussion regarding the causes and consequences of immigration policies. Several issues had to be put aside, in order to emphasize the ones that I felt were especially important. The rest of this chapter addresses the strengths, but also the limitations of the study, while opening doors to future research. The next sections organize this discussion around three central themes of the dissertation: the industry-immigration nexus, the gap between public opinion and policies, and the consequences of immigration for innovation and technological change. I then conclude with an epilogue emphasizing broader implications for world politics.

5.1 The Industry–Immigration Nexus

The evidence reported in Chapter 4 supports the view that there is a tight connection between the industry mix and the political management of the skill composition of immigration. The results of that chapter have shown that Canadian provinces whose economies depend largely on more traditional, low-technology industries are more likely to receive higher shares of unskilled immigration than provinces in which the high-technology sector strives. Of course, an exogenous shock to the provincial industry mix generates an impact whose magnitude depends on how one defines the different sectors. I have shown that the policy response is roughly proportional to changes in the industry mix when considering a categorization of sectors combining low and mid-technology industries together. In turn, policies help to maintain the specialization of provinces. I was able to support those conclusions after implementing a 2SLS estimator allowing me to make the distinction between each side of this relationship. Those results were replicated using an Arellano-Bover/Blundell-Bond model for dynamic panel data analysis, and are also consistent with the findings of the second chapter.

Those findings stimulate a discussion about the future of immigration policies in a country like Canada. According to the theory, demand for unskilled immigrants is likely to persist as long as industries relying upon traditional production methods remain important national actors. Moreover, assuming that everything else remains the same, governments will keep having incentives to admit migrants with lower levels of education. This type of projection appears to contradict the common wisdom that Canadian immigration policies are strongly biased toward the selection of skilled migrants, notably after the implementation of the point system in 1967. However, the findings of this dissertation suggest a different interpretation: point systems and other selection mechanisms matter politically, not only to boost the absolute proportion of skilled immigrants, but more importantly to customize policies in response to the needs of industries. The findings of Chapter 3 bring support to the view that temporary workers have played an important role in addressing industry needs during the past decades. As mentioned at the end of that chapter, several initiatives have been implemented to facilitate the issuance of temporary work visas for specific types of unskilled workers in Canada (Abbott and Beach, 2011; CIC, 2012*a*). The theory introduced in this dissertation helps to explain the motivations behind the admission of unskilled immigrants, and suggests that future policies will continue in that direction, unless major exogenous shocks interfere with the industry mix.

A limitation to my argument about the skill composition of immigration is that the proposed mechanism explaining the relationship can hardly be observed empirically. I have claimed that governments seek to preserve the support of corporate interests, and fear the consequences that would result from a reduction in the size of specific sectors—in particular, traditional and labour-intensive industries, which already face acute labour resource constraints. In other words, my argument suggests that governments are averse to change, and that they use policies in order to countervail the radical transformations that would otherwise affect the makeup of national industries. However, only the implications of this theory could be tested. Thus, I cannot entirely rule out alternative explanations that would predict the same behaviour.

Nonetheless, the inner mechanism of my theoretical argument appears plausible in light of relevant pieces of legislation in Canada. Section 10(2) of the 2002 IRPA makes it clear that regional economic concerns are crucial in the decision-making process. The section states that the federal government "must consult with the governments of the provinces respecting the number of foreign nationals in each class who will become permanent residents each year, [and] their distribution in Canada taking into account regional economic and demographic requirements [...]" (Canada, 2013*i*, 8). Therefore, my argument that governments use immigration policies to maintain the balance in the regional industry mix fits well into the general policy goals openly stated by legislators. Testing whether elected officials are specifically concerned with the depletion of traditional industries could be achieved with complementary research. For instance, elite interviews could eventually help to further our understanding of how executives deal with concerns regarding the mix of industries in Canada when managing immigration policies.

5.2 The Immigration Gap Paradox

A concrete attempt to explain the paradoxical gap between the preferences of voters and observed policy outcomes was proposed in Chapter 3. This paper used detailed data on lobbying in Canada to give an innovative portrait of the influence of the corporate sector on immigration policies, which could explain why governments tend to shift from the ideal policy position of the average voter. Descriptive data introduced in that chapter showed that national industries care a great deal about the issue of immigration, having lobbied governments intensively during the past 15 years. I have also confirmed the existence of a strong relationship between the intensity of corporate lobbying and inflows of temporary workers, which cannot be caused by the market-driven part of the temporary worker program. In contrast, however, the response of permanent immigration to lobbying appeared much less robust. Appendix A presents additional results that were not included in Chapter 3.

The stronger result obtained when considering temporary workers was not an explicit prediction of the theoretical model, and deserves discussion. One possible interpretation is that governments consider the admission of temporary workers to be less damageable for their popularity than permanent immigrants. The problem is that little survey data are available to estimate the electoral cost of expansive temporary immigration, compared to permanent immigration. Results from a CBC/Nanos survey published in December 2012 revealed that a majority of Canadian respondents oppose or somewhat oppose the admission of temporary workers (Nanos, 2012), suggesting that the public is not particularly enthusiastic about this type of policy tool either.[1] Nonetheless, it may be the case that temporary worker inflows do not draw as much media attention as permanent immigrants, making the former a more appealing policy instrument for governments. Testing the relevance of this interpretation would be a task for future research. Another possible interpretation has been mentioned in the conclusion of Chapter 3, namely that temporary work visas are more flexible to accommodate the needs of national industries, hence may be preferred to permanent immigration by the corporate sector itself.

On the other hand, the weak finding regarding levels of permanent immigration in Chapter 3 also suggests that the immigration gap paradox is not completely resolved. A possible reason is that the channels of influence from special interests to policy-makers extend beyond lobbying activities. For instance, the preferences of the corporate sector over immigration levels may be well-known to governments even before the beginning of

[1]Notice that the survey question asked whether respondents support or oppose "[a]llowing temporary foreign workers into Canada *while Canadians qualified for those same jobs are looking for work* [emphasis added]" (Nanos, 2012, 4), a framing that is hardly comparable to the question used to assess positions on permanent immigration in Canadian election studies.

a mandate. Moreover, the available measures of the intensity of lobbying efforts may capture the influence of special interests only imperfectly. Future empirical research may benefit from the 2008 Lobbying Act in Canada, which now requires lobbyists to reveal more details about their conversations with public officials. This means that the analysis of Chapter 3 could be eventually replicated using an even more accurate measure.

5.3 Immigration and Innovation

A last central theme of this dissertation is the relationship between immigration and innovation. This theme is highlighted in Chapter 2, which reassessed the economic impact of immigration based on recent developments in economic theory. The chapter focused on the role of labour resources for business R&D, an important source of technological change. I made use of empirical estimates to simulate the impact of immigration policies on business R&D, based on the assumption that immigrants and natives of the same skill levels are equivalent. I found that the typical immigration policy in OECD countries tends to depress the intensity of business R&D, and has little effect on the absolute levels of R&D outlays. Importantly, those findings emphasize an overlooked macroeconomic implication of immigration policies, namely that those policies tend to slow down the otherwise booming expansion in high-technology industries. The results of Chapter 4 brought additional support to the claim that the skill composition of immigration affects the prevalence of high-technology sectors.

A key empirical result of Chapter 2 is the elasticity of business R&D intensity with respect to unskilled labour, which is greater in absolute magnitude than the corresponding elasticity with respect to skilled labour. In a nutshell, this implies that skilled labour must increase over-proportionally in order to heighten the intensity of private research. I have argued that immigration policies generating an equal increase in the supplies of unskilled and skilled workers tend to depress the intensity of business R&D. Basically, it would take a lopsided proportion of skilled migrants to stimulate business R&D using immigration. For instance, suppose that skilled workers represent 25% of the stocks of labour in a recipient country. In that case, and considering the estimates based on the Barro and Lee (2010) data set presented in Table 2.4, skilled immigration would have to be 1.3 times larger than unskilled immigration to avoid negatively affecting the intensity of R&D, holding constant the stocks of capital.[2] The skill composition of immigration remains far from that level in the Canadian case when considering all sources of admission (see Chapter 4). In contrast, stocks of skilled labour in the working-age population as a whole have increased more than six times faster than unskilled labour in the past decades across OECD countries, which explains (along with the rapid growth in physical capital) why the private R&D sectors have experienced a drastic expansion.

It is worth emphasizing that technological change—i.e. the change in the technology level induced by successful R&D activities—is widely considered to be the most important component of economic growth (see the discussion in Helpman, 2008). Put simply, the only way to improve life conditions is to produce goods or services more efficiently with the same quantity of inputs, which is precisely the intuitive definition of technological change. Technological change matters not only for the growth in production per capita, it also contributes to the size of output, since producing more with the same quantity of inputs also increases the total quantity of goods produced. Therefore, it appears that one of the most important questions to address when studying the economic impact of immigration concerns the implications for innovation and technological change. The empirical evidence

[2] To see this, let S represent the number of skilled immigrants, U the number of unskilled immigrants, $H = 0.25$ the initial stocks of skilled labour, and $L = 0.75$ the initial stocks of unskilled labour. The percent increase in H caused by immigration corresponds to $\frac{S}{0.25}$, and the percent increase in L to $\frac{U}{0.75}$. The results in the upper panel of Table 2.4 (computed with measures of H and L based on tertiary educational attainment rates) indicate that the impact of immigration on the intensity of business R&D is approximately zero when $\frac{S}{0.25}/\frac{U}{0.75} = 4$, in other words when $S \approx 1.3U$.

presented in Chapters 2 and 4 brought forth an original contribution to a scarce literature on that specific question, exploiting data on business R&D expenditures.

Interestingly, the findings of Chapter 2 revive earlier thoughts raised in the literature on induced innovation. In 1962, Habakkuk formulated the hypothesis that labour scarcity stimulates technological change, in his seminal comparative study of the United States and Great Britain. 19th century America provides rich illustrative examples to support this thesis. For instance, many economic historians agree on the idea that the scarcity of land labourers during the Civil War fostered the adoption of inventions designed to augment productivity in the sector of agriculture (Hutchinson, 1935; Olmstead, 1975; David, 1975). Indeed, this period marked the spread of Cyrus McCormick's mechanical reaper and John Deere's steel plow, inventions that drastically reduced the need for mass labourers in order to harvest fields. The results of Chapter 2 appear consistent with Habakkuk's thesis, with the additional precision that the relative scarcity of unskilled labour stimulates business incentives to invest in research. Other recent pieces of literature have reached similar conclusions (see e.g. Romer, 1990*a*; Grossman and Helpman, 1991; Zeira, 1998; Acemoglu, 2002; Beaudry and Collard, 2003). Under this perspective, it may be the case that the labour shortages anticipated for the next decades in Western countries represent a blessing rather than a curse. Scarcer labour may actually stimulate inventions that we cannot yet envision, which would help firms to produce more efficiently with less workers.

5.4 Epilogue

A goal of political economy is to understand how policy outcomes affect the allocation of resources, and which factors drive those policy outcomes in the first place. Immigration, in particular, raises a number of concerns in terms of its implications for the recipient economy, even more so since labour represents a fundamental factor of production. To complicate matters further, immigration policies represent an issue of contention, over which the preferences of national actors are conflicting. My dissertation points to an important conclusion shedding light on those issues. I have shown that immigration policies are largely shaped by concerns for national industries, but that they have collateral consequences by tempering down the growth in the intensity of high-technology sectors. To reach such a conclusion, I have exploited the idea that factors of production are closely linked to the national industry mix, a promising framework for future research. Given the paucity of existing works on those issues, my hope is that such conclusions will contribute to a constructive debate, and help to advance our comprehension of the relationship between labour policies and the economy.

In is worth noting that when presenting my main argument, I have deliberately restricted my focus to recipient countries. But the research program initiated in this dissertation could be readily extended to study the global consequences of international migration. If the skill composition and levels of immigration can affect the industry mix in recipient countries, we may reasonably expect non-trivial consequences for emigration countries as well. Salt (1992) raised an important concern when he claimed that the foreign workers most beneficial to recipient countries—skilled migrants—are precisely the ones that emigration countries would prefer to keep. My results appear consistent with such an interpretation, by showing that skilled labour is closely linked to key indicators for economic development. A relevant question to ask, therefore, is whether a skilled worker from the developing world contributes more to the global economy by moving to an OECD country, or by making use of their skills at home. In other words, a natural extension to this dissertation would seek to find whether the international allocation of labour resources is globally optimal, and how immigration policies affect the world economy.

Appendix A

Alternative Measure of Corporate Lobbying

This appendix presents further details regarding the measurement of corporate lobbying in Chapter 3, along with robustness tests that were not included in the paper.

As explained in Chapter 3, the database of the Canadian *Office of the Commissioner of Lobbying* contains all registration records made by lobbyists since 1996. To construct the corporate lobbying measure used in the empirical analysis of that chapter, I have considered as primary units of analysis all records associated with a specific registration number (those registration numbers are allocated by the Office). Each of those records is also associated with an effective date (the date at which the record became effective) as well as an end date. The measure of corporate lobbying is based on the sum of all records active during a quarter—including those who had been active only during a fraction of that quarter—and for which the client was identified as a business or an organization representing businesses.

The measure of corporate lobbying has some limitations, discussed in both Chapter

3 and the concluding chapter of the dissertation. Before the 2008 Lobbying Act, the registration records did not include information about the date of communication between lobbyists and public officials. In order to have a consistent measure of corporate lobbying efforts throughout the time-period 1996-2011, I did not take into account information about the date of communication made available after 2008.

However, I show below that the findings of Chapter 3 are robust to changes in the indicator used to measure the intensity of corporate lobbying. A different way to capture the variation in lobbying activities is to count only the number of registrations becoming effective in each quarter. Such an indicator can be interpreted as a measure of the short-run change in the intensity of lobbying. By neglecting the fact that registration records may remain active during several quarters, this new indicator captures only a part of the actual fluctuations in corporate lobbying activities, and is less accurate than the main measure. For this reason, the alternative indicator was not included in the final version of Chapter 3. Nonetheless, replicating the analysis with this alternative measure may help to reinforce the conclusions drawn in that chapter.

Table A.1 replicates the cross-correlations reported in Table 3.2 between lobbying and the two types of immigration—economic migrants and temporary workers—using the alternative indicator counting only the new lobbying registration records per quarter. As can be seen, the correlation patterns are similar to the ones previously found in Chapter 3. The lags of the new corporate lobbying indicator are positively and significantly related to the two immigration series—in fact, the correlation coefficients are larger than the ones initially reported in Table 3.2. On the other hand, the leads of Lobbying are also significantly related to the two immigration series, for a larger number of periods.

Next, Figure A.1 replicates the forecast error impulse response functions presented in the top panels of Figure 3.4, based on a new VAR(6) specification that is identical to

Table A.1: Cross-Correlations between Lobbying and Types of Immigration (Alternative Measure of Lobbying)

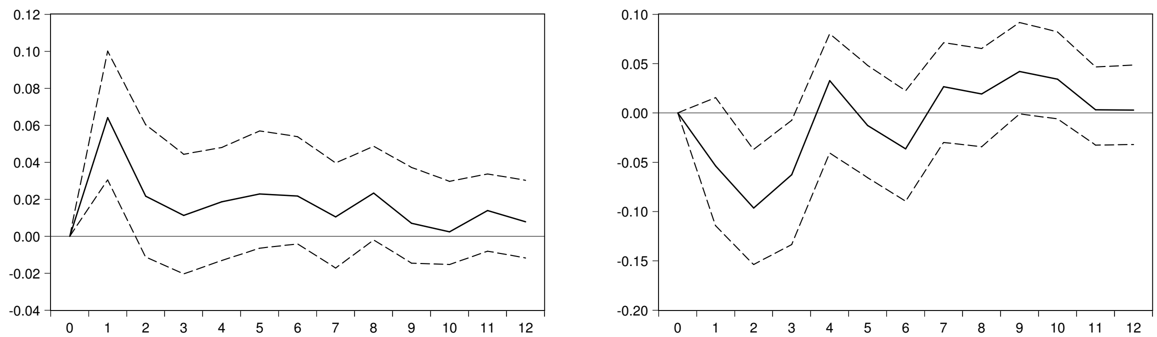
	Economic, Lobbying($t \pm i$)			Workers, Lobbying($t \pm i$)	
i	Lag	Lead	i	Lag	Lead
0	0.733*	0.733*	0	0.429*	0.429*
1	0.756*	0.705*	1	0.328*	0.464*
2	0.735*	0.627*	2	0.302*	0.446*
3	0.723*	0.600*	3	0.348*	0.426*
4	0.704*	0.543*	4	0.402*	0.378*
5	0.682*	0.485*	5	0.415*	0.339*
6	0.670*	0.446*	6	0.410*	0.350*
7	0.641*	0.403*	7	0.424*	0.315*
8	0.639*	0.367*	8	0.443*	0.247
9	0.581*	0.287*	9	0.467*	0.180
10	0.569*	0.239	10	0.440*	0.096
11	0.548*	0.173	11	0.376*	0.059
12	0.509*	0.136	12	0.315*	0.092

Replication of the cross correlations between corporate lobbying and economic migrants (left panel), and temporary workers (right panel), for up to 12 lags and leads of the Lobbying series. Correlations are considered significant if they exceed the value of $\pm\frac{2}{\sqrt{T}} = 0.25$ ($T = 64$). The Lobbying measure is based on the count of new lobbying registration records from the corporate sector on the issue of immigration (rather than the total count of active records).

the first one used in Chapter 3, except for the Lobbying measure, which is now based on the new indicator just described. As can be seen, the estimated response of the Workers series is still positive and significant in the first period after an exogenous shock in the Lobbying series. I made use of Hall 95% error bands, computed with 1000 bootstrap replications, as I did in the empirical analysis of Chapter 3. The estimated elasticity is lower in magnitude when using this indicator, which is consistent with the idea that the new measure accounts for a smaller part of the variation in corporate lobbying activities. The accumulated response after two years now corresponds to 0.2. In other words, an exogenous 1% increase in the number of *new* registration records from corporate lobbyists on the issue of immigration induces a 0.2% response in the levels of temporary workers admitted to Canada, distributed over two years.

Figure A.1: Forecast Error Impulse Responses (Alternative Measure of Lobbying)

(a) Lobbying → Workers (b) Lobbying → Economic



As for the Economic series, its response is negative in the short run, and becomes positive two years after an initial shock in Lobbying. A similar pattern was found in Chapter 3 when using orthogonalized impulse responses (see Figure 3.6(b)). Once again, those findings support the interpretation that temporary workers and economic migrants are substitutes. The accumulated long run elasticity of Economic with respect to the new Lobbying measure is undistinguishable from zero, as was found in Chapter 3 using the measure accounting for all active registration records.

In summary, the signs of the relationships of interest remain similar when considering an alternative measure of corporate lobbying on the issue of immigration, based solely the quarterly number of new registration records.[1] Thus, even though the available measures may not fully capture the temporal variation in lobbying efforts, the results appear robust to the use of alternative indicators.

[1]I considered another indicator when performing the empirical analysis Chapter 3, accounting for the importance of each lobby. This alternative indicator gave a weight to each corporate actor based on the total number of records filed during the whole period 1996-2011. In other words, if a specific actor of the corporate sector filed 10 records during the whole period, each of its active records per quarter would take the value of 10. The signs of the relationships obtained using this weighted measure were once again similar to those reported in Chapter 3. However, since this weighted measure has a less convenient interpretation, I did not report those additional results.

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