Four Essays on Fiscal Decentralisation and Secessions

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Four Essays on Fiscal Decentralisation and Secessions

Thèse de Doctorat

Présentée et soutenue publiquement par

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de Hull (Québec, Canada)

le 6 octobre 2016

en vue de l'obtention du grade de

Docteur ès sciences économiques et sociales
délivré par l'Université de Fribourg

et

Docteur en sciences économiques
délivré par l'Université d'Avignon et des Pays de Vaucluse

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Fribourg (Suisse), 2016

Résumé

Entre 1945 et 2008, le nombre de pays reconnus internationalement a augmenté de 74 à 193 (Spolaore, 2008). Plus récemment, plusieurs pays ont vécu une vague croissante de décentralisation. Dans les pays de l'OCDE, par exemple, le nombre de gouvernements infranationaux a atteint 140 000 en 2014. De plus, ces gouvernements infranationaux ont une influence croissante dans ces pays (OCDE, 2014).

Compte tenu de ces tendances vers une décentralisation croissante, cette thèse étudie deux aspects de celle-ci : la concurrence fiscale, et le choix endogène des frontières.

En matière de concurrence fiscale, cette thèse étudie la mise aux enchères de nouveaux investissements par une firme à plusieurs établissements. Le but de cette analyse est d'étudier le comportement stratégique de la firme dans ce type de concurrence. En effet, contrairement à la littérature sur le sujet qui ne considère soit que des firmes à établissement unique, ou un continuum de firmes, le premier chapitre de thèse montre que la firme peut modifier l'allocation de ses investissements en les différentiant, pour ainsi attirer des subsides plus élevés. Dans le deuxième chapitre, la thèse étudie comment l'ajout de coûts en infrastructure par les régions avant la mise aux enchères affecte la concurrence entre les régions ainsi que le comportement de la firme. En effet, ces coûts ajoutent un nouveau compromis pour la firme. Elle peut augmenter les subsides espérés en différentiant ses établissements, mais en augmentant la taille d'une des usines, elle peut aussi inciter les régions à renoncer à participer à la mise aux enchères, ce qui peut finalement réduire les subsides.

En matière de choix endogène des frontières, cette thèse fournit deux analyses: une empirique, et une expérimentale. Dans le troisième chapitre, la thèse étudie empiriquement la décision d'électeurs dans 213 villes du Québec de quitter une fusion municipale qui leur fût imposée quelques années auparavant. L'analyse révèle que les électeurs choisissent de faire sécession d'autant plus quand les différences de revenus et de langue entre leur ville et les autres villes de la même fusion sont plus élevées. L'analyse révèle aussi que ces deux facteurs ne sont

pas indépendants. En effet, les différences de revenus ont un effet plus prononcé sur le vote sécessionniste lorsque les différences de langue sont aussi élevées. Etant donné l'importance de la langue comme facteur déterminant de l'appartenance ethnique au Québec, les résultats de ce chapitre suggèrent que le choix des électeurs est sensible aux différences ethniques, et non seulement à des différences de goût pour les biens publics, comme suggéré par Alesina, Baqir et Hoxby (2004).

Finalement, le dernier chapitre présente les résultats d'un expérience en laboratoire sur le lien entre décentralisation et sécession. La littérature sur le sujet suggère l'existence de deux effets contradictoires. La décentralisation pourrait permettre de contrer les mouvements de sécession en permettant aux régions de prendre plus de décisions à un niveau local, mais pourrait aussi fournir des ressources supplémentaires aux mouvements sécessionnistes, ce qui renforcerait les tendances vers la séparation. Nous construisons donc une expérience en laboratoire dans laquelle les sujets sont chacun membre de deux groupes: un local comportant 3 sujets, et un global comportant 9 sujets. Les sujets contribuent à un total de trois biens publics, soit avec les membres de leur groupe local, ou avec les membres de leur groupe global. En variant le nombre de biens de chaque type, l'expérience simule différent niveaux de décentralisation. Les résultats de l'expérience montre que l'effet total de la décentralisation est de diminuer la probabilité de votes pour la sécession.

Acknowledgements

First, I would like to thank my two supervisors, Thierry Madiès and Pierre-Henri Morand, for their guidance through the research process and the trust they put in me. Through almost daily contacts, Thierry Madiès helped me keep my research on track and focused on the most important questions. While geographic distance kept me from as frequent discussions with Pierre-Henri Morand, I left every meeting with him feeling immensely more knowledgeable and ready to tackle the next part of my research. I am grateful to both of them, who went above and beyond their duties as doctoral supervisors.

I would also like to thank the members of the jury for having accepted to evaluate my thesis. In particular, I thank Philippe De Donder and Sonia Paty for acting as referees, and Martin Huber, Nicolas Gravel, Marko Köthenbürger, and Enrico Spolaore for taking the time to read my work and provide comments.

This doctoral thesis benefited from the financial support of the Chair of Regional and International Economics of the University of Fribourg. I also received a generous grant from the Conférence des recteurs des universités suisses (CRUS) in support of international doctoral co-supervisions, thus allowing for regular visits to Avignon and other universities as well as summer schools and conferences.

During the preparation of this thesis, I was fortunate enough to visit a number of academic departments and research centres. I would like to thank Jean-François Tremblay for hosting me at the University of Ottawa, Nicolas Gravel for hosting me at the Aix-Marseille School of Economics, Antti Moisio, Janne Tukiainien, and Tuukka Saarimaa for hosting me at the VATT Centre for Economic Research in Helsinki, Jim Alt for hosting me at the Institute for Quantitative Social Sciences of Harvard University in Boston, as well as Philippe Bontems, Philippe De Donder, and Karine Van der Straeten for hosting me at Toulouse School of Economics. At each of these departments, I was able to meet several like-minded researchers who helped me improve the work in this thesis.

For the experimental part of this thesis, I would like to thank Quentin Thévenet who programmed the experiment, as well as Marie-Claire Villeval for her guidance in preparing an economic experiment for the first time. I would also like to thank all the staff and researchers at the research laboratory of the Groupe d'analyse et de théorie économique (GATE) who welcomed us every time we went to Lyon to conduct experiments.

I would like to thank my friends and colleagues at the University of Fribourg, both the other PhD students and the professors. As colleagues, they proved valuable interlocutors in many fruitful discussions on economic research. As friends, they made the five years it took to write this thesis much more enjoyable. In particular, I would like to thank Tjaša Bjedov, with whom I shared not only an office, but also many research collaborations and, perhaps most importantly, a friendship.

Finally, I am grateful for the life-long support of my parents. They imparted to me the importance of education and knowledge, and encouraged me to follow my ambitions, even when it was difficult to see me leave overseas.

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Introduction

Between 1945 and 2008, the number of internationally recognised countries increased from 74 to 193 (Spolaore, 2008). Concurrently, in the last two decades, many countries experienced a wave of decentralisation. For example, in OECD countries, the number of sub-national governments reached 140,000 in 2014. Moreover, in these countries, the trend in the past twenty years is towards more influence and decision power for sub-national jurisdictions (OECD, 2014). This trend is also spreading to developing countries (Dafflon and Madiès, 2012).

Against this background of increased decentralisation, this thesis will investigate two issues pertaining to it: fiscal competition, and the choice of jurisdiction borders. Regarding fiscal competition, the OECD (2014) points out that increased autonomy for sub-national governments is likely to induce more tax competition. Most of the literature on tax competition considers competition for a continuum of firms, investigating, for example, whether fiscal competition leads to a race to the bottom and a lower provision of public goods (for a review, see Wilson (1999) and Keen and Konrad (2014)). In the first part of this thesis, I will focus on a different type of fiscal competition: bidding wars between regional governments to attract new investment from firms. Moreover, I analyse how these bidding wars affect the firm's structure, thus putting the spotlight on the strategic choices of the firm, instead of the governments'. These bidding wars represent an appreciable amount of public spending. In fact, in the United States alone, state and local governments award approximately $80 billion in tax incentives each year to companies.[1] In the first two chapters, I build theoretical models to study such bidding wars when the firm decides to build multiple new plants. Since firms usually make multiple investment decisions in short amounts of time, the location decisions may not be independent, a feature ignored by most of the literature that either considers a single mono-plant firm or an infinite number of mobile firms.

[1] The New York Times, "As Companies Seek Tax Deals, Governments Pay High Price," available at the following address: http://www.nytimes.com/2012/12/02/us/how-local-taxpayers-bankroll-corporations.html.

Another important aspect of fiscal decentralisation is the design of borders and how to delegate political power. Oates (1972), for example, proposed that there was an optimal split of responsibilities between local and central governments. Later, Alesina and Spolaore (1997) studied how borders are decided endogenously, based on a trade-off between economies of scale and heterogeneity of preferences. In the second part of the thesis, I look at the endogenous formation of borders, first empirically using a set of municipal referendums on secession in Canada, and then with experimental methods, investigating how decentralisation affects votes for secession.

In the remainder of this general introduction, I summarise the main points of each chapter and explain how they contribute to their respective literatures.

Chapter 1 analyses bidding wars for plants of a multi-establishment firm. The main question is whether the firm can allocate investment across its production sites strategically, in order to increase the subsidies she receives from regional governments. The focus is thus mostly on the firm's strategic behaviour, instead of the governments'. To analyse this question, Chapter 1 presents a model of a bidding war between regions to attract one of two new plants from a firm. The firm chooses how much to invest in each establishment, and then uses a multi-unit auction to "sell" them to regional governments. The latter have private benefits from hosting the firm on their territory. These benefits are private knowledge and represent, for example, spillovers to domestic firms, a reduction in unvoluntary unemployment, or more intangible benefits to the local politicians making the decision.[2] The assumption that regions have private benefits is similar to those made by Martin (1999, 2000), as well as Ferrett and Wooton (2013). An important aspect of this assumption is that the regions have private knowledge, and reflects the idea that the firm does not know beforehand which region values the plant the highest.

In contrast to these papers and to most of the literature, however, I consider a bidding war where a single firm makes multiple plants available to the regions. A notable exception in the literature is the anaylsis of Haaparanta (1996), who also studies a multi-unit bidding war, but under perfect information. Since information asymmetry is an important justification to use an auction (or a similar mechanism) in the first place, the model of Chapter 1 provides an original and significant improvement over Haaparanta's (1996) model. The fact that the firm can install more than one new plant has additional implications. Indeed, her behaviour is more

[2] Buts, Jegers, and Jottier (2012) find that subsidies to firms increase support for incumbent local politicians in Belgium.

complex; she has to decide how much to invest in each location. Finally, note that since this chapter discusses the allocation by a firm of production across many plants, it also contributes to the literature on the decision of firms to produce in multiple establishment. Examples include Hanink (1984) and Behrens and Picard (2008).

I model the auction process as a simultaneous open ascending auction for multiple units. The firm runs an ascending clock that determines the current price for the smallest plant still available. Regions quit the auction when the clock price reaches a certain level depending on their benefits. Once only two regions remain in the bidding war, the subsidy for the smallest establishment is set at the amount on the clock when the third-to-last region left the auction. If the two plants were of equal size, the auction stops there, and the last two regions each win one of the plants at that price. If the two plants are of unequal size, the remaining two regions continue bidding for the larger establishment. The subsidy is then set at the amount of the clock when the second-to-last region leaves the bidding war.

The model is a three-stage game. First, the firm chooses and commits to amounts of capital to invest, based on her expectations of subsidies and last-period operating profits. Then, she runs the auction, which determines the equilibrium subsidies. In the last period, the firm invests the capital in the winning regions, produces, and receives operating profits.

The main results of Chapter 1 are as follows. First, I find that equilibrium subsidies will depend on the firm's choice of capital amounts to invest. In particular, when she chooses asymmetric plants, total subsidies are larger, due to the infra-marginal competition between the last two remaining bidders for the larger plant. Indeed, when only two regions remain, they are both guaranteed to win at least the small plant, and continue bidding until one is indifferent between winning either plant and withdraws. Cowie et al. (2007) previously considered infra-marginal competition in the context of an auction. They analyse how a seller can divide the units for sale in multiple lots in order to receive higher offers from the bidders. They find that differentiating the lots can lead to higher bids due to the infra-marginal competition for the largest lot. I have a similar reasoning in the auction stage of the model.

Second, I show that this bidding behaviour affects the optimal investment amounts of the firm. More specifically, I find that she always chooses to differentiate her establishments. In particular, the subsidies can be interpreted as "adjustments" to the marginal cost of labour. Essentially, since the regions' benefits depend on the amount of labour employed, so do the subsidies offered by the regions. When the firm invests more, she hires more workers and pays higher total wages, but this increase is mitigated by larger subsidies.

I then compare this result to a situation without a bidding war, in which the firm simply chooses two locations for the plants randomly.[3] First, I look at how the bidding war changes investment in each plant individually. I find that the bidding war increases the size of the first establishment for any distribution function of the private benefits and for any production function. The modification to the second establishment, however, is ambiguous and depends on the shape of the distribution of private benefits. For a simple uniform distribution, the bidding war always increases the size of the second plant, but with very skewed distributions, it is possible to find cases where bidding war reduces the size of the investment. Second, I investigate how the bidding war affects total investment. The modification is ambiguous in general, but when using a Cobbs-Douglas form for the production function, I find that total investment increases. Notably, this result is true for any distribution function.

In the final section of the chapter, I discuss the optimal mechanism to allocate the establishments under three different sets of assumptions: first from the point of view of the firm, second from the point of view of a social planner, and finally under more relaxed assumptions on the firm's commitment.

First, I consider the choice of the open ascending auction as the formal procedure to "sell" the plants. More specifically, I find the optimal mechanism from the point of view of the firm, to maximise her total profits. I find that this optimal mechanism, defined by an allocation and a payment rules, can be implemented by the open ascending auction. Since the optimal mechanism also describes reserve subsidies, I also characterise conditions under which these reserve subsidies are non-binding.[4]

Second, I solve a similar problem, but from the point of view of a social planner. I find that an uninformed social planner would choose identical allocation and payment rules as the firm. Therefore, the optimal mechanism implemented by the firm is socially efficient. However, as in typical mechanism design problems, the firm can choose not to allocate if the revealed signals are under a certain threshold (i.e., reserve subsidies). In the firm's optimisation problem, I described conditions under which these reserve prices don't come into play. In the social planner's problem, I do the same, showing that these conditions are more relaxed under the social planner. In effect, the social planner allocates the plants more often. In other words,

[3] In the model, I deliberately assume that the firm has identical productivity in every region.

[4] These reserve subsidies are equivalent to reserve prices in an auction. It's the level of subsidies under which the firm decides not to allocate the plants.

the social planner puts less importance on the firm's capture of the informational rent of the regions.

Finally, I also find the optimal mechanism under the assumption that the firm can choose how much to invest endogenously through the mechanism. I find that this unconstrained optimal mechanism without prior commitment to amounts of investment leads to the same allocation and payments, in expected value, as the constrained optimal mechanism (with commitment). Therefore, while in the auction model, the firm could choose, *ex post*, to renege on her commitment and change the amounts of investment once the information is revealed, this commitment doesn't change the outcome of the model in expected values. However, the correspondence between the *ex ante* and *ex post* profits of the firm obviously depend on the revealed information of the regions. In the model, I choose to keep the obligation of the firm to commit to investments to keep the model tractable and focused on the question of how the firm's production split affects, and is affected by, the bidding war.[5]

To conclude, the first chapter contributes to the literature on fiscal competition, and more specifically to the branch that considers competition for a specific firm. To summarise, this chapter can be interpreted as two successive additions to the usual literature on bidding wars for firms. First, instead of considering a fixed investment, this chapter allows the firm to choose the amount to invest and make available in a bidding war. This addition changes the strategy of the firm, inciting her to over-invest in comparison to a situation without a bidding war. Second, we add a multi-location component: the firm can allocate the total investment across two sites. This addition modifies the firm's behaviour further, by inciting her to differentiate the amounts of investment between the production sites. In doing so, she continues to over-invest in total. Put simply, Chapter 1 shows that the strategic behaviour of firms has important implications on the bidding wars for plants between regions.

In terms of social welfare, the chapter shows that while the allocation of investment is distorted versus a situation without a bidding war, the positive effect on allocative efficiency resulting from bidding wars is preserved in a multi-plant bidding war. More specifically, the regions that value the investment the most win it. Moreover, not only is total investment increased (which may have positive or negative implications), but it is increased (under some

[5]Such a modification to the model would most likely necessitate a dynamic model, since once the firm changes the investment amounts, the regions can also modify their subsidies, so that the firm may prefer to cancel the bidding war and start over with the information gained in the previous auction. I leave that possibility for future research.

conditions) for both hosts of the plants. Therefore, the increase in investment is not skewed only towards one of the winners at the expense of the other.

In Chapter 2, I present a second analysis of bidding wars for multi-plant firms. I depart from the first chapter by considering a second tool often used by regional governments: improvements in productive infrastructure. For example, Davies (2005) lists a number of cases of subsidies to large plants where local governments also offered road, sewer, and rail improvements as part of the incentives. Since the firm will only choose a subset of all regions in the bidding war, it is possible that some of that infrastructure spending is "wasted." Taylor (1992) makes the theoretical argument that this spending is indeed wasted, but Jayet and Paty (2006) and Justman et al. (2002) instead argue that such investment spending can be welfare-improving.

These authors, however, consider either a competition for a single mono-plant firm or for a continuum of many firms. In light of Chapter 1's result, we might suspect that the multi-plant nature of most firms conducting these bidding wars could have consequences on the competition for these plants. The goal of this chapter is to determine how such infrastructure costs can affect the outcome of the bidding war, as well as the behaviour of the firm. Indeed, when the firm conducts multiple bidding wars simultaneously, she also chooses the size of each establishment. Choosing a larger establishment (e.g., by choosing asymmetrical establishments) has consequences for the needs in infrastructure. For example, bigger plants may use more electricity, need better roads, etc. While all regions may have a level of public infrastructure sufficient to host a plant up to some threshold size, larger plants may require additional infrastructure. This additional infrastructure is modelled in Chapter 2 similarly to an entry cost in an auction: a sunk cost that is necessary in order to participate in the auction.

The argument in Chapter 2 is therefore the following. When allocating plants through a bidding war, the firm differentiates her establishments, thus concentrating more production in one plant than without a bidding war. In turn, this concentration increases the size of one plant, and thus the infrastructure needed to host it. Consequently, some regions decide not to invest in the necessary infrastructure, and do not take part in the bidding war. Finally, this lower competition for the firm's investment potentially reduces the subsidies she hopes to receive. At one extreme, only one region enters the bidding war, completely differentiating itself from the others, and wins the firm's investment without paying subsidies.

To analyse this question, I build a modified version of the model in Chapter 1. To focus on the production *split* of the firm, I set total investment to an exogenous amount, thus limiting the choice of the firm to a single variable representing the share of investment in each plant. The timing is similar, but before the auction takes place, the regional governments must decide whether they want to pay an infrastructure cost to take part in the bidding war for the largest plant. This cost depends on the share of production previously chosen by the firm, and makes the region fit to host the plant (i.e., it corresponds to the level of infrastructure needed to the level required by the larger plant).

I also choose a simplified, reduced-form function for the firm's profits. To show that this reduced-form profit function captures the important features of the multi-plant bidding war, I first solve the model without entry costs, finding the same results as in Chapter 1 for certain parameters of the profit function (namely, the parameters that ensure the firm has incentives to split production without a bidding war).

In the following section of the chapter, I consider the full model, including the endogenous entry of regions. The main results are as follows. First, I show that by choosing a high differentiation (a large share of production in one plant), the firm risks driving all regions out of the bidding war. Indeed, since the infrastructure cost is sunk, when it is too large, regions are better off only participating in the bidding for the small establishment.

Second, I show that this feature of the competition has implications on the firm's choice of differentiation. Indeed, when infrastructure costs are important enough, even a firm that would usually be better off concentrating all production in a single plant would choose to split in two establishments. More generally, these infrastructure costs mitigate the tendency of the firm to put more production in one of the establishments, thus moving closer to identical plants.

To conclude, Chapter 2 expands on the first chapter, and shows that when the regional governments can make investment in public infrastructure before the bidding war, the firm modifies her allocation of production. In brief, this public investment reduces the incentives for the firm to differentiate her plants.

In Chapter 3, I turn to the study of endogenous borders and secessions. This question has had a relatively high profile in recent years at a national level, especially following the vote of the United Kingdom to leave the European Union, but also due to the debates in Scotland and Catalonia, for example. However, similar issues were raised at a more local level, when central governments in recent decades have modified borders of municipalities, promising cost savings and higher efficiency. Examples include municipal mergers in Finland, Japan, and Canada, as well as the push towards more collaboration amongst French municipalities.

However, as evidenced by the Canadian case, voters often have priorities diverging from local governments when it comes to the borders of local jurisdictions. In fact, the economic literature on endogenous borders often emphasises a trade-off between economies of scale and heterogeneity of preferences (see, e.g., Alesina and Spolaore, 1997). Larger jurisdictions can more efficiently provide public goods, but there might be a better match between the preferences of voters and the public good in smaller jurisdictions. Alesina, Baqir, and Hoxby (2004) put forth another reason for the disapproval of large jurisdictions by voters: voters inherently dislike living in a jurisdiction with people different from them. This reason is closely linked to the literature on the provision of public goods in diverse communities. For example, Alesina et al. (1999) as well as Algan et al. (2016) show that the co-existence of different ethnic groups in municipalities or communities can lead to public goods of lower quality (e.g., vandalism in Algan et al. (2016)).

The objective of this chapter is to investigate whether preferences, ethnic identity, or both arguments explain the voters' disapproval of large jurisdictions. To do so, I use data from a set of municipal referendums in the Canadian province of Quebec. After the provincial government unilaterally enforced a wave of municipal mergers in 2001, public opposition led to a change of government in the following elections. Having campaigned on the idea of reversing these mergers, the new government organized, in 2004, simultaneous public consultations in the 213 cities that were part of the merger wave. In this consultation process, voters were asked whether they wanted their pre-merger town to secede from the consolidated municipality or not. In the analysis, I use the consultation results as the dependent variable, and look at the effect of a number of socio-economic factors on whether a town decides to secede or not, using Probit estimations.

These referendums are unique and allow for an original and interesting analysis. Indeed, while many authors studied the determinants of municipal or local mergers before, they usually had to rely on the decisions of public officials (e.g., Austin, 1999; Brasington, 2003, Hanes et al. 2009; Saarimaa and Tukiainen, 2014). However, Hyytinen, Saarimaa, and Tukiainen (2014) show that government officials can choose mergers based on other priorities, such as career concerns. For example, a merger might increase competition for their council seat. Some authors used referendums before, but their dataset or their analysis was limited. Brink (2004), for example, uses data from only a few referendums over 20 years, and these referendums were requested by the cities themselves. Tanguay and Wihry (2008) also use data from the referendums in Quebec, but while they find that differences in income and language separately affect the secession decision, they do not attempt to explain why. In this chapter, I shed light on whether preferences for an ethnically homogeneous community are important in addition to simple preferences for the public good, using the full sample of 213 cities[6] and including important additional variables such as differences in house values.

Since municipalities in Quebec have different language compositions, the mergers often mixed mostly English-speaking towns with French-speaking ones. Since in Quebec, language is at the foundation of a strong ethno-lingustic identity, I can investigate whether greater differences in language composition resulted in more secessions. Moreover, since income and language are not perfectly correlated, I can refine the analysis, by analysing, using interaction terms, whether differences in language affected how voters were swayed by income differences.

My main results are as follows. First, differences in income and language between a town and the other towns in the merger are important drivers of the secession decision. Second, while greater income differences does lead to more secessions, I find that this effect is not identical at different levels of language differences. In particular, when voters are mixed mostly with others of the same ethnic group (i.e., low language differences), they tolerate differences in income: income differences have no, or only a small effect on the probability of a secession. However, when the language differences are larger, differences in income greatly affect the probability of a secession. These results suggest that when deciding to secede, voters do not only care about the match between their preferences for the public goods and the public goods provided, but also directly care about the ethnic identity of the voters in their jurisdiction. In other words, voters prefer ethnically homogenous municipalities. This result is robust to many specifications, including accounting for turnout at the referendum, as well as to the inclusion of a spatial lag.

In addition, I find that while the size of income differences affect the probability of secession, they only do so in absolute value; the direction of that difference has no effect. Simply put, it is not richer or poorer towns that secede, only those that are more different in either direction. Moreover, I find that while income differences are important, differences in house values (which are correlated with income differences, and define the tax base) have no robust effect on secession. The analysis also accounts for differences in political preferences. However, due to the nature of political parties in Quebec (i.e., federalist vs. secessionist), this variable is closely correlated with language and captures much of the same effect.

[6]Tanguay and Wihry use a different dependent variable that limits the sample.

Chapter 3 has two main conclusions. First, it shows that questions of ethnic identity are important in the voters' preferences over jurisdiction borders. This finding contrasts with much of the economic literature on municipal mergers, but also secessions in general, which focuses on the the match of preferences between voters and the public goods provided. Second, and more concretely, the chapter shows that if governments care about the potential long-term benefits of ethnic diversity in local jurisdictions (as suggested by Putnam (2007) and Ottaviano and Peri (2005)), they should impose mergers and commit to a policy of not allowing further changes.

The last chapter of this thesis, Chapter 4, also studies secessions. It investigates, using experimental methods, the link between decentralisation within a country and the presence of secessionist groups. In particular, the objective of this chapter is to find whether decentralisation increases or decreases the probability votes for regional secession. Indeed, when central governments are confronted with a secessionist threat in one or more regions, they might devolve some power or competences to the regional entity, in the hope that the decentralization of power will accommodate regional demands and thereby quell the separatist movement. However, while decentralisation might allow an overall mix of public goods closer to the voters' preferences, it might also provide more resources to the secessionist movement, thus making them more organised and possibly stronger. This double-edged sword argument was brought forward by Lustick, Miodownik, and Eidelson (2004), and Spolaore (2008), for example.

Spolaore (2008) cites a few empirical studies that tackle this question, highlighting, however, that such empirical studies are bound to face measurement and endogeneity issues. Moreover, while secessions occur in the real world, they are still relatively rare and can be difficult to compare using data. Nevertheless, authors such as Bakke and Wibbels (2006) find that ethnic conflicts are more common in federations, when regions have different incomes. Brancati (2006), in her analysis, finds that decentralisation reduces the likelihood of conflict, but that this effect can be counteracted by the increasing support for regional parties.

Given the difficulty to find causal estimates with observed data, Chapter 4 instead approaches the question with experimental methods. To this purpose, I build an original experimental design based on a multiple public good game using the voluntary contribution mechanism (Isaac and Walker, 1988). The experimental design is as follows. When subjects arrived at the lab, they were placed in groups of 9 (hereafter, global groups). At the same time, these global groups were split into 3 smaller groups, called local groups (of 3 subjects each). Therefore, subjects played public goods game at two levels: local and global. All 9 subjects in a global group contribute to the global public goods. At the local level, subjects can only contribute to the local public goods corresponding to their local group. Additionally, the marginal per capita returns (MPCR) of these two types of public goods are different. Namely, the MPCR is 0.5 for the local public goods and 0.2 for the global public goods.

In all treatments, the subjects contribute to three public goods for 24 periods. The configuration of the three public goods (i.e., the number of local and global goods) differ according to the treatment. After the 24 periods, subjects vote on whether they want their local group to "secede" from the global group. After the vote, subjects play an additional 12 periods, under the institutional arrangement decided by the votes. When a local group successfully votes to secede, they only contribute to local public goods in the last 12 periods.[7]

The experiment uses a 2×2 design. Treatments vary on the two dimensions of decentralisation and local group identity. First, for the decentralisation dimension, we vary the number of each type of public goods. In the Centralisation treatments, subjects are faced with two global public goods and one local public good, while in the Decentralisation treatments they are faced with the opposite: one global public good and two local public goods. Second, for the identity dimension, we introduce variation in how we create local groups. In the No identity treatments, subjects are randomly assigned to local groups. In the Identity treatments, groups were constituted based on the proximity of subjects' opinions in a preliminary questionnaire. Each local group is formed with subjects that share the closest opinions.[8]

The implementation of decentralisation in this experiment is obviously very simplified, and does not consider, for example, how local goods differ from national ones. However, the experimental design still captures some of the real-world features of decentralisation for three reasons. First, since there are more subjects in the global groups, monitoring is more difficult, and a greater level of free-riding might be expected. In fact, Fellner and Lünser (2008), in a similar experiment with local and global public goods, find that contributions fall more rapidly in the global good. Consequently, the setup captures at least part of the rationale for decentralisation: the provision of public goods at the local level is more easily monitored, being "closer" to the voters. Second, provision at the global level is more efficient in the experiment than at the local level. While the MPCR for the global good is lower, there are more participants, and

[7] In the first 24 periods, subjects are familiarised with that institutional arrangement. Specifically, they play 12 periods under a mixed environment and 12 periods in an environment that only includes local public goods.

[8] When local groups are formed using the questionnaire, subjects are aware that the assignment method will place them with like-minded people. Like others in the literature, the idea is that such a treatment reinforces the shared identity among local groups.

thus the potential payoff is higher. Third, since public goods of the same type (local or global) are identical experimentally, we might fear that subjects put the whole amount they decided to contribute to that type in a single good. In that case, our experiment would be essentially equivalent to a experiment with only two public goods. However, Bernasconi et al. (2009) show that subjects contribute more to public goods when there are many identical goods. If our subjects first consider the two categories of goods as distinct, and then how much to contribute to each good individually, then the multiple identical local goods actually capture the fact that "more spending" is being done at that level. In fact, the subjects in the experiment of Chapter 4 actually contribute more to goods that are duplicated, thus alleviating potential concerns that subjects would consider two identical goods as a single good.

The second treatment dimension is related to the the findings of Chapter 3 on the link between ethnic identity and the probability of a secession. Given the importance of ethnicity in many secessionist movements around the world, and the role of identity in experimental results (Tajfel and Turner, 1979; Chen and Li, 2009; Chakravarty and Fonseca, 2012), the experiment introduces the same concept to investigate whether the creation of a local shared identity modifies the outcome of the vote. In addition, I consider whether this identity creation modifies the effect of the Decentralisation treatment. Indeed, in the real world, decentralisation might be more or less efficient at stopping secessionist movements depending on the strength of the ethnic identity of the region.

The results of Chapter 4 concern both the results of the vote and the level of contributions by subjects. First, it finds that the Decentralization treatment strongly decreases the probability that subjects vote for secession, although reinforced local identities have no effect on the votes. Second, the results also show that the Decentralization treatment increases contributions to the local public goods. However, the Identity treatment does not affect the level of individual contributions. To conclude, the results suggest that central governments could actually weaken secessionist movements by devolving some responsibilities to regional governments.

Chapter 1

The Impact of Bidding Wars on the Optimal Investment Decisions of Multi-Establishment Firms[1]

[1]This chapter was prepared in collaboration with Pierre-Henri Morand. I acknowledge the help of Thierry Madiès, who provided useful comments on this chapter, as well as Nicolas Gravel and Tanguy van Ypersele for helpful discussions and suggestions. This chapter was presented at the Annual Meetings of the Association for Public Economic Theory (Luxembourg, 2015).

1.1 Introduction

Tax incentives offered to firms in exchange for new investments represent an appreciable amount of government spending each year. In the United States alone, state and local governments award approximately $80 billion in tax incentives each year to companies.[2] These subsidies are often the result of bidding wars between many local or regional governments. Owing to their prominence, economists investigated the behaviour of firms and governments participating in these location contests. However, they have generally considered a single firm opening a single establishment. In fact, the firms running these bidding wars are frequently multinationals, or at least multi-establishment companies. For example, between 2007 and 2012, Boeing received at least $327 million in incentives from 11 US states. In the same period, Procter & Gamble received at least $128 million from 10 states.[3] These examples illustrate how firms make multiple investments in short periods of time. Consequently, these bidding wars are not necessarily independent.

In this chapter, the objective is to investigate the strategic behaviour of a firm that is conducting a bidding war for multiple establishments. The main question is whether the firm can allocate investment across its production sites strategically, in order to increase the subsidies she receives from regional governments. The focus is thus mostly on the firm's strategic behaviour, instead of the governments'. To do so, we propose a model in which regional governments are competing against each other to attract one of a firm's investments. The main originality is twofold. First, the firm endogenously decides how much to invest, and her decision can affect the bidding behaviour of the regions. Second, we allow the firm to invest in more than one location, essentially making multiple plants available for bidding. Formally, we model this competition as a multi-unit auction. We find that such a bidding war affects the firm's structure. Indeed, the firm invests more in one of the plants, creating differentiation between them. In doing so, she creates incentives for the regional governments to offer larger tax breaks, through infra-marginal competition between the last two remaining bidding regions for the largest plant in the auction. Cowie *et al.* (2007) previously considered infra-marginal competition in the context of an auction. They analyse how a seller can divide the units for sale in multiple lots in order to receive higher offers from the bidders. They find that differentiating the lots can lead to higher

[2]The New York Times, "As Companies Seek Tax Deals, Governments Pay High Price," available at the following address: http://www.nytimes.com/2012/12/02/us/how-local-taxpayers-bankroll-corporations.html.

[3]Other examples are available from the New York Times, at the following URL: http://www.nytimes.com/interactive/2012/12/01/us/government-incentives.html

bids due to the infra-marginal competition for the largest lot. We have a similar reasoning in the auction stage of our model.

This chapter contributes mainly to the literature on fiscal competition, but also to the analysis of the location decision of multinationals. To the literature on fiscal competition, this chapter is particularly related to the subset of papers that consider competition for a single large firm. Keen and Konrad (2014) offer a short overview of this literature, which includes early contributions by, e.g., Black and Hoyt, (1989), Doyle and van Wijnbergen, (1994), and King *et al.*, (1993). This is in contrast to the larger stream of that literature that considers the competition between regions or countries to attract units of homogeneous and perfectly divisible capital. Wilson (1999) and Keen and Konrad (2014) offer extensive surveys of these models. Moreover, in contrast to many of these papers, we are primarily interested in how bidding wars affect the strategy and the behaviour of the firm, instead of governments.

As in this chapter, many papers that investigate these bidding wars for a single large firm use models from, or similar to, auctions. Indeed, auctions are a useful tool for sellers who do not know the value potential buyers place on the product sold. Moreover, as suggested by Klemperer (2004, Chapter 2), auction theory can also provide a rich set of tools to study a number of problems in economics and social sciences. Location contests are a good example of a context in which auctions are a useful theoretical tool; many bidders (governments) place some private value on a good (investment), and a seller (the firm) does not know how to price it, thus choosing to accept bids (subsidies).

Our model is particularly related to the analysis of Haaparanta (1996), who uses a menu auction model. This author considers two regions competing for investment from a firm, under the assumption that this investment is divisible. However, while Haaparanta (1996) considers a model under perfect information, we assume that the regions' private benefits from hosting the firm are private knowledge. In fact, such information asymmetry is a justification to use a mechanism similar to an auction in the first place.

As the model will show formally, analysing the question under an open ascending auction instead of a menu auction (as in Haaparanta's paper) will reveal new insights about the bidding war and the allocation of investment. First, when establishments are asymmetric, infra-marginal competition takes place between the last two remaining bidders, increasing the subsidy on the large plant, and allowing the firm to benefit from higher total subsidies. Consequently, at the equilibrium, the firm modifies her allocation of production to take advantage of this phenomenon. Cowie et al. (2007) previously considered infra-marginal competition in the context of an auction. They analyse how a seller can divide the units for sale in multiple lots in order to receive higher offers from the bidders. They find that differentiating the lots can lead to higher bids due to the infra-marginal competition for the largest lot. I have a similar reasoning in the auction stage of the model. The second new insight results from the presence of information asymmetry. Under a menu auction, Haaparanta (1996) finds that the firm captures the whole rent from the regions. In this chapter, the information asymmetry curbs the firm's ability to extract rents from the regions.

Another closely related paper is that of Martin (1999). This author studies two firms in the same industry who use bidding wars sequentially to decide where to locate. Martin (1999) shows that agglomeration effects incite regions to overbid in the first auction, expecting it will increase their probability of winning in the second period. Indeed, winning the investment in the first period from the first firm increases the attractiveness of the region to other firms in the same industry. In this chapter, we also find that regions offer greater subsidies for one plant. However, we consider how a single firm can entice greater subsidies by modifying her allocation of production between two plants. In addition, we do so without considering agglomeration economies.

Other related papers include Black and Hoyt (1989) who were, to our knowledge, the first to explicitly model the firm's location choice as an auction. They highlight the fact that this competition need not be a zero-sum game; the bids offered by government can promote the efficient location of production. In their model, they also consider that smaller, already established firms may move once a new firm is opened in one of the regions. Indeed, small firms will relocate to the winning region, thus increasing its potential gains. This multiplier effect can explain why regions may seem to "overbid" for the large firm.

Before Black and Hoyt (1989), Doyle and van Wijnbergen (1994), in a paper first published in 1984, considered a bargaining game between one firm and a government over taxation. Doyle and van Wijnbergen (1994) assumed that firms negotiate with a single government at a time. In their solution, the host government initially sets a low tax rate, but gradually increases it until it reaches a limit. The government has some bargaining power due to the fact that the multinational must incur a positive cost if it relocates to a new location. However, firms have no reason not to negotiate simultaneously with multiple governments. Recognising this fact, Bond and Samuelson (1986) investigate a situation in which a firm has to decide between two locations. In their model, tax holidays are used as a signal of productivity by the governments. An important feature of their model is information asymmetry. It allows for the presence of tax holidays even if there are no fixed costs, in contrast to Doyle and Van Wijnbergen (1984). Similarly to Bond and Samuelson (1986), information asymmetry is an important of our model, although our results are derived without productivity differences between the regions.

Black and Hoyt (1989) had highlighted some caveats to their analysis. One caveat was the lack of dynamic considerations. King and Welling (1992) explore the consequences of allowing the firm to relocate in later periods. They consider a two-period model, in which the firm conducts an auction to decide on its location in each period. They find that when players cannot commit to second-period actions, the firm can re-locate to the region that lost in the first period. This possibility modifies the first-period bids, thus changing the outcome even if the relocation threat is not materialised. The authors also show that the firm would prefer a world with commitment, but that without commitment, total social welfare is higher.

King, McAfee and Welling (1993) generalise the model of King and Welling (1992), but with a continuum of local productivities. They also consider an extension in which regions can invest in infrastructure in a previous stage, thus increasing their productivity potential. They find that in equilibrium, regions tend to choose different levels of infrastructure, thus endogenously creating the productivity continuum described in their main model. King et al. (1993) assume some information asymmetry, but it is the firm who does not know its productivity in each region. In this chapter, we instead assume (like Martin, 1999) that the regions hold some private information, while productivity is the same everywhere. This modelling choice reflect the fact that not all regions value the firm's presence identically.

In this chapter, we also do not consider a two-period model. The firm installs new production facilities in one period, but we do not model the interactions in the following periods. We do so deliberately, to focus instead on how the firm decides to allocate across regions in multiple establishments in a single period. If we did consider many periods, our results could be related to those of Janeba (2000), for example, who considers a firm that installs excess production capacity in multiple regions in order to avoid the problem of hold-up by the regions. Indeed, in subsequent periods, regions could increase taxes or renege on their commitment to tax breaks (i.e., subsidies). By having excess capacity, the firm could credibly threaten to decrease production, and thus employment in the region that increased taxes, to increase it in the other.

Furusawa, Hori and Wooton (2010) show that the bidding mechanism can affect the results of the model. In their paper, they show that English auctions lead to more aggressive bidding, or to a "race beyond the bottom," compared to bidding in sealed bid auctions. Martin (2000), however, cites case studies that claim bidding wars resemble more closely open ascending auctions, as in our model. Menezes (2003) describes the basic competition for investment under several auction mechanisms, and shows that the expected amount paid to the firm is the same, which is not surprising given the Revenue Equivalence theorem. In this chapter, we show that the open ascending auction we use implements the optimal mechanism (under some conditions).

Other examples of papers on bidding wars for a specific firm include Ferrett and Wooton (2010), who analyse the question of firm ownership, showing that tax or subsidy offers are independent of the ownership country of the firm. In another paper, Martin (2000) applies auctions with favouritism to study these contests when firms have explicit preferences for a region. Finally, Scoones (2001) studies bidding wars for firms when the value of the investment has two components: common and private. In other words, part of the investment's value is the same in every region, while another is specific to producing in a given region. He shows that if the common share increases, then the subsidies increase as well, eventually transferring all value to the firm.

Some may see these bidding wars as wasteful, but they can also play an important role in eliciting private information and improving allocation efficiency (Menezes, 2003). In fact, despite paying subsidies to the firm, the winning region may actually benefit from the presence of the new plant. Greenstone and Moretti (2003) compare the outcomes for winning and losing counties in contests for "million dollar plants", and find that winning counties experience greater increases in land value as well as in the total wage bill of other firms in the industry of the new plant. In our model, we show that this bidding war ensures that regions that value the investment the most are those receiving it, a favourable outcome in terms of social welfare. We also show that the differentiation between the plants is optimal from the point of view of a social planner.

In addition to the literature on fiscal competition, this chapter is related to the analysis of the multinational. Indeed, one of our contribution over most papers cited above is to allow the firm to have multiple establishments, and investigate how a bidding war affects the firm's choice of production locations. Ekholm and Forslid (2001) explain how Core-Periphery models argued that firms prefer to concentrate in a single location, as long as trade costs are low enough. These two authors then depart from the usual Core-Periphery models and investigate firms that have multi-plant economies of scale, and thus produce in many regions. They cite the example of soft drink and beer manufacturers, who usually operate in numerous locations. Their model points to less agglomeration than previous models did. Hanink (1984) offers another potential justification for multi-plant firms: risk diversification. He does so by comparing firms to investors. In the same way that investors prefer holding a diverse portfolio, firms can hold a diverse "geographical" portfolio to increase their overall profits. These papers show that firms can have incentives to operate in many plants. In this chapter, we take as given the existence of multi-plant firms, focusing instead of the location decision of these firms, and how it is affected by a bidding war.

More closely related to this paper, Behrens and Picard (2008) study the choice of firms to become multinationals, in a model that includes subsidies to location. They find that bidding wars and subsidies affect the choice of firms to become multinationals, in effect increasing the number of multinationals. In their model, they consider a continuum of firms deciding to locate in one or two countries. In this chapter, we instead study the choice of a single firm, taking its decision to be a multinational as a given. However, their result underlines the importance to study bidding wars in the context of multinationals.

Our main results are as follows. First, we show that when a firm conducts a bidding war for multiple establishments, she can increase her total profits (operating profits plus subsidies) by differentiating her establishments. Second, we show that under certain assumptions on the production function, the firm invests more in total and receives larger subsidies under such a bidding war than she would if she allocated production without relying on a bidding war. Third, we show that total investment and subsidies would be over-estimated if we did not consider the linkages between the bidding wars between the multiple establishments of a single firm. Fourth, we show that the multi-unit auction under which we derive our main results is equivalent to the optimal mechanism from the firm's viewpoint. Similarly, we show that a social planner would also choose the same allocation and payment rules, although the conditions under which the social planner chooses not to impose reserve prices are looser than the conditions from the firm's viewpoint. Finally, although our model is derived with a commitment to investment amounts by the firm in the first period, we show that in expected value, our model is equivalent *ex ante* to a more general model without commitment.

The next section presents the framework of the model, including the timing of the game.

Section 3 solves the three stages of the game, while Section 4 compares the results with those of an alternative model with only one plant, but with an endogenous amount of investment. This model shows how both endogenous investment and multiple investments affect the firm's behaviour. Section 5 derives the optimal mechanism, first from the viewpoint of the firm, and then from that of a social planner. Then, it derives the optimal mechanism without prior commitment to investment amounts, showing that it is *ex ante* equivalent in expected value to the constrained optimal mechanism. The last section concludes.

1.2 The Model

Consider a firm that plans to build new production facilities in two of n regions, indexed by $i \in 1, ..., n$. To decide the location of these plants, the firm puts the n regional governments in competition against each other. The governments submit offers of subsidies to attract the firm to their territory. In contrast to most of the previous literature, however, the firm can divide her production in multiple locations, either in symmetric or asymmetric establishments. For simplicity and tractability, we limit the model to the case of two establishments, indexed by $j \in 1, 2$. Without loss of generality, we label the largest plant by $j = 1$, so that $K_1 \geq K_2$.

1.2.1 The Firm

We consider a multinational firm that already produces elsewhere, and wants to increase production by installing new establishments among the n regions. Once she decided where to install the new plants, the firm produces, in each establishment, according to the production function $f(K_j, L_j)$, with K_j the capital invested in location j, and L_j the labour employed in that establishment. We make the usual assumptions that the production function exhibits decreasing returns to scale in both inputs ($\frac{\partial f(K_j,L_j)}{\partial K_i} > 0$, $\frac{\partial f(K_j,L_j)}{\partial L_i} > 0$ and $\frac{\partial f^2(K_j,L_j)}{\partial K_i^2} < 0$, $\frac{\partial f^2(K_j,L_j)}{\partial L_i^2} < 0$).[4] The firm sells the product on a global market for a price p, acting as a price-taker. We deliberately do not model the goods market explicitly, to instead focus on the firm's location decision and the bidding war between regions. The production costs are identical in every region (w, r). Therefore, the firm's operating profits in each establishment $j = 1, 2$ are equal to

$$\pi_j = pf(K_j, L_j) - wL_j - rK_j \tag{1.2.1}$$

[4]This assumption implies, in the model, that the firm has incentives to produce in more than one establishment.

In addition to the profits from production, the firm also receives subsidies from the regions (resulting from the bidding war), so that her total *ex post* profits are equal to:

$$\Pi = s_1^* + s_2^* + \pi_1 + \pi_2 \tag{1.2.2}$$

where s_j^* is the equilibrium subsidy for establishment j.

1.2.2 The Regions

These subsidies depend on the regions' valuation of the firm's investments. In particular, if regional government i wins establishment j, it receives a payoff equal to

$$V_{ij} = L_j \cdot b_i - s_{ij} \tag{1.2.3}$$

where L_j is the number of persons employed by the firm in establishment j, b_i is the level of private benefits from hosting the firm for region i's government, and s_{ij} is the subsidy (bid) offered to the firm by region i when winning establishment j. The subsidy can be interpreted as a total "fiscal package" offered to the firm.[5]

A region's private benefits b_i are private knowledge, and they capture, for example,[6] an increase in labour taxation from workers who will be employed by the firm, as well as spillovers to domestic firms, but also the compatibility of the firm for the region. Indeed, if the industry of the firm has a bad reputation in one region, the regional government would put only a small value on the firm's investment (due to, for example, re-election concerns).[7] The private benefits are identically and independently distributed according to a distribution $g(\cdot)$ on some interval $\left[\underline{b}, \bar{b}\right]$ (with $\underline{b} \geq 0$).

1.2.3 The Auction Process

The equilibrium subsidies are then determined by an auction in which the firm takes the role of the auctioneer, and the regional governments submit their bids to host the firm's plants.

[5]In effect, our model assumes that all regional governments have the same basic tax rate, but differentiate themselves with targeted tax holidays that may differ. This assumption may not be unreasonable in the case of sub-national jurisdictions. Even when considering countries, we are mostly interested in the competition taking place in subsidies, and abstracting from tax competition allows us to focus on our variables of interest.

[6]Ferrett and Wooton (2013) use a similar justification for private benefits, while Martin (2000:6) provides a more thorough list of potential explanation for these benefits.

[7]For example, Buts, Jegers, and Jottier (2012) find that subsidies to firms increase support for incumbent politicians.

Since there are two establishments available, the firm conducts a multi-unit auction, with both establishments available simultaneously.

The formal mechanism is an open ascending auction. More specifically, the firm runs an ascending clock, representing the current price for the lowest-value establishment still available (the one with the lowest investment). Regional governments still in the running are ready to offer a bid equal to the current price. The winning bid is determined from the price on the clock when the previous bidder withdrew from the auction. In particular, if the two establishments are still available, then when there are only two regions left bidding, the price for the lowest-valued establishment will be determined from the clock price at which the third-to-last region withdrew from the auction.[8] These two remaining regions will then continue bidding until one of them exits. The clock price at which the second-to-last region withdrew will be the price for the highest-valued establishment. Formally, this mechanism is a type of second-price auction.

1.2.4 Timing

We can summarize the timing of the whole game as follows.

Stage 0: Nature picks the set of $\{b_i\}_{i=1,\dots,n}$. Regional governments learn their b_i.

Stage 1: The firm chooses and commits to an allocation of capital (K_1, K_2), anticipating the subsidies offered by governments resulting from the auction in Stage 2, and the firm's own profit maximization in the last stage.

Stage 2: The multi-unit auction takes place. Winning regions offer s_1^* and s_2^*, based on their expectation of the labor that will be employed by the firm (from profit maximzation in the last stage).

Stage 3: The firm invests capital K_1 and K_2, as determined in Stage 1, in the winning regions. She then maximizes her profits, taking capital fixed, choosing L_1 and L_2.

In the first stage, the firm commits to a certain allocation of capital. One could reasonably argue that the firm has incentives to deviate from that allocation once she receives the subsidies from the region. However, in that case, regions would anticipate these deviations and bid accordingly. To facilitate the analysis, we make the assumption that the firm can credibly commit to her allocation.

[8] Note that regions who withdraw from the auction without winning one establishment do not pay anything.

1.3 Equilibrium Subsidies and Firm Location Choice

We will solve the game described in the previous section by backwards induction.

1.3.1 Stage 3: Production

We first solve the last stage of the game, to find the firm's optimal labour input demand in each firm for each level of capital invested. At this stage of the game, the firm already knows the identity of the winning regions, and invests the capital in these two regions as determined in the first stage. She also knows how the amount of the subsidies conditional on the amount of labour she will employ.

The firm thus maximizes her profits in each plant, choosing L. At this last stage of the game, the firm already decided on (K_1, K_2), so it is fixed. Her maximization problem in each plant is thus as follows.

$$\max_{L_j} \quad pf(K_j^*, L_j) - wL_j - rK_j^* \tag{1.3.1}$$

The first-order condition is

$$pf'(K_j^*, L_j) - w = 0$$

implying that the firm chooses L_j to equalize the marginal product that input, $f'(K_j^*, L_j)$, with the ratio of w and p. Therefore, the optimal L_j will depend on the amount of capital invested, K_j^*. We define the function $L(K_j)$, determining the amount of labour employed for each possible equilibrium level of capital invested in the first stage.

Since the regions' valuation depends on the amount of labour employed, we want to know how L varies with K. By totally differentiating the first-order condition, we can obtain the sign of $\frac{dL}{dK}$:

$$\frac{dL}{dK} = -\frac{\frac{\partial^2 f(K^*,L^*)}{\partial K^2}}{\frac{\partial^2 f(K^*,L^*)}{\partial K \partial L}} > 0$$

This derivative is greater than zero as long as the cross partial derivatives in K and L are positive (e.g., increasing capital increases the marginal product of labour). Therefore, a greater investment by the firm in an establishment translates into a greater valuation of that establishment by the regions.

As an example, take a simple Cobb-Douglas production function $f(K, L) = K^\alpha L^\beta$ with $\alpha + \beta < 1$. At that stage, K is fixed in each establishment and the firm already received the subsidies. Therefore, the firm chooses L in each plant to maximise her operating profits. In that case, for each level of K, she chooses an optimal amount of labour L equal to

$$L(K) = \left(\frac{p\beta}{w}\right)^{\frac{1}{1-\beta}} K^{\alpha/(1-\beta)} \tag{1.3.2}$$

In this example, larger investments by the firm translate in more labour employed ($L'(K) > 0$), but at a decreasing rate ($L''(K) < 0$).

1.3.2 Stage 2: Auction and Equilibrium Subsidies

In the auction stage, the firm puts up two plants for sale of sizes K_1 and K_2. The regional governments expect the firm to employ $L(K_1)$ and $L(K_2)$, respectively, and bid according to their valuation functions V_{ij}. The following lemma describes the equilibrium subsidies resulting from the auction.

Lemma 1.1. *The equilibrium bids for the two establishments will be equal to*

$$s_2^*(K_1, K_2) = L^*(K_2) \cdot b_{(3)} \tag{1.3.3}$$

$$s_1^*(K_1, K_2) = (L^*(K_1) - L^*(K_2))b_{(2)} + L^*(K_2)b_{(3)} \tag{1.3.4}$$

where $b_{(z)}$ is the z^{th}-highest signal among the n regions.

Proof. To see why these two bids are optimal, take a region i with private benefits b_i and assume that everyone else bids according to the following strategy: continue bidding until the clock reaches my private valuation. In that case, if the clock reaches L_2b_i and there are still 3 or more regions in the auction, then region i has no incentive to continue bidding. Indeed, if she does, whatever the stop price, she will need to pay more than her valuation if she wins. Therefore, at price L_2b_i, she prefers to leave the auction. Now consider prices lower than L_2b_i, for example L_2b_l. At that clock price, region i has a positive valuation and would like to win. Therefore, she has no incentive to leave the auction. Therefore, the equilibrium bid for the small establishment will be equal to

$$s_2^*(K_1, K_2) = L(K_2) \cdot b_{(3)}$$

where $b_{(3)}$ is the third-highest signal among the n regions.

If the two plants are of symmetric sizes (i.e., $K_1 = K_2$), then the two remaining regions each pay $s_2^*(K_1, K_2)$ and each receive the same investment.

However, if the two plants are asymmetric (i.e., $K_1 \neq K_2$), we still have to determine which region receives the largest investment. Both regions know that their possibilities are now to pay $s_2^*(K_1, K_2)$ and receive the small establishment, or to pay more and receive the large establishment. The bid for the largest establishment will thus be determined by the infra-marginal competition between the two remaining bidders. Since at that point, the auction becomes a simple second-price auction between two bidders, it is optimal for both regions to simply withdraw once the clock price reaches their valuation of the large plant. If they continue past that price, they either win and pay a price higher than their valuation, or they lose and pay the price for the second establishment, which was already determined.

Take the decision problem of the region with the second-highest private benefits.[9] It will be indifferent between the two establishments when

$$L(K_1)b_{(2)} - s_1^*(K_1, K_2) = L(K_2)b_{(2)} - s_2^*(K_1, K_2)$$

By rearranging this equation and substituting the value of $s_2^*(K_2)$ found earlier, we obtain the value of the highest bid

$$s_1^*(K_1, K_2) = (L(K_1) - L(K_2))b_{(2)} + L(K_2)b_{(3)}$$

■

Note that, as expected, if $K_1 = K_2$, this equation is equal to $s_2^*(K_1, K_2)$. In the more interesting case of asymmetric investments, however, the two last remaining regions continue to compete for the large establishment. We see, from equation 2.6, that an increase in K_1 for a given value of K_2 raises, through the infra-marginal competition, the subsidy offered for the most valuable establishment. A reduction in K_2 has a similar effect, while also reducing the bid received for the small investment.

[9] Given the monotonicity of the valuation function of the regions, for any level of private benefits, regions prefer the largest establishment to the small one.

1.3.3 Stage 1: The Firm's Optimal Location Choice

In the first stage, the firm's optimisation problem is the following:

$$\max_{K_1,K_2} E(s_1^* + s_2^* + \pi_1 + \pi_2) \tag{1.3.5}$$

where $\pi_j = pf(K_j, L_j) - wL_j - rK_j$ and s_j^* are, respectively, the operating profits in each establishment and the equilibrium subsidies as determined in Lemma 2.1. The firm thus chooses K_1 and K_2 to maximise her total expected profits, anticipating the bids of the regions, as well as her profit maximisation in the last stage. The solution to this optimisation problem leads to the following proposition.

Proposition 1.1. *When the firm allocates her production units through a multi-unit auction, she always chooses to differentiate the two establishments ($K_1 \neq K_2$).*

Proof. The firm does not know the private benefits of the regions in the competition, but knows that they are distributed according to $g(\cdot)$ on the interval $[\underline{b}, \overline{b}]$. Her objective function can thus be expressed as

$$\begin{aligned} E(\Pi) = \int_{\underline{b}}^{\overline{b}} \int_{\underline{b}}^{b_{(2)}} \Big[&(L(K_1) - L(K_2))b_{(2)} + 2L(K_2)b_{(3)} \\ &+ pf(K_1, L(K_1)) - wL(K_1) - rK_1 + pf(K_2, L(K_2)) - wL(K_2) - rK_2 \Big] \cdot \\ &h(b_{(2)}, b_{(3)}, n)db_{(3)}db_{(2)} \end{aligned} \tag{1.3.6}$$

where the last part $h(b_{(2)}, b_{(3)}, n) = n(n-1)(n-2) \cdot \Big[1 - G(b_{(2)})\Big] \Big[G(b_{(3)})\Big]^{n-3} g(b_{(2)})g(b_{(3)})$ is the joint distribution of $b_{(2)}$ and $b_{(3)}$, and $L(K_j)$ is the equilibrium amount of labour for a level of capital K_j. We obtain the following first-order conditions:

$$\begin{aligned} \frac{\partial E(\Pi)}{\partial K_1} = &L'(K_1)E(b_{(2)}) \\ &+ p(\frac{\partial f(K_1, L(K_1))}{\partial K_1} + \frac{\partial f(K_1, L(K_1))}{\partial L(K_1)} \cdot L'(K_1)) - wL'(K_1) - r = 0 \end{aligned}$$

$$\begin{aligned} \frac{\partial E(\Pi)}{\partial K_2} = &-L'(K_2)E(b_{(2)}) + 2L'(K_2)E(b_{(3)}) \\ &+ p(\frac{\partial f(K_2, L(K_2))}{\partial K_2} + \frac{\partial f(K_2, L(K_2))}{\partial L(K_2)} \cdot L'(K_2)) - wL'(K_2) - r = 0 \end{aligned}$$

Since $L(K)$ represents equilibrium values, the FOCs can be simplified using the Envelope Theorem.We then obtain:

$$\frac{\partial E(\Pi)}{\partial K_1} = L'(K_1)E(b_{(2)}) + p\frac{\partial f(K_1, L(K_1))}{\partial K_1} - wL'(K_1) - r = 0 \quad (1.3.7)$$
$$\frac{\partial E(\Pi)}{\partial K_2} = -L'(K_2)E(b_{(2)}) + 2L'(K_2)E(b_{(3)}) + p\frac{\partial f(K_2, L(K_2))}{\partial K_2} - wL'(K_2) - r = 0 \quad (1.3.8)$$

Combining the two FOCs, we see that

$$p\left(\frac{\partial f(K_2, L(K_2))}{\partial K_2} - \frac{\partial f(K_1, L(K_1))}{\partial K_1}\right) = L'(K_2)\left(w + E(b_{(2)}) - 2E(b_{(3)})\right) - L'(K_1)\left(w + E(b_{(2)})\right)$$

We want to show that $K_1 \neq K_2$. Let's first assume that $E(b_{(2)}) \neq E(b_{(3)})$ (i.e., we focus on the interesting cases where the firm expects regions to have different valuations). To prove that the firm has to optimally split in asymmetric establishments, we first assume that she does not, and show that it leads to an inconsistency. Indeed, if $K_1 = K_2 = K$, the previous equation reduces to

$$0 = 2L'(K)\left(E(b_{(2)}) - E(b_{(3)})\right)$$

Since the regions have different expected private benefits, this equation is true only if $L'(K) = 0$. However, that derivative is always positive. Therefore, we conclude that $K_1 \neq K_2$.

■

Note that we can rearrange the first-order conditions as such:

$$p\frac{\partial f(K_1, L(K_1))}{\partial K_1} = L'(K_1)(w - E(b_{(2)})) + r \quad (1.3.9)$$
$$p\frac{\partial f(K_2, L(K_2))}{\partial K_2} = L'(K_2)(w + E(b_{(2)}) - 2E(b_{(3)})) + r \quad (1.3.10)$$

This formulation is informative of the trade-offs at play. In each establishment, the firm's choice of K_j reflects the usual trade-off of marginal revenues and marginal costs. However, the marginal cost of labour is not simply equal to the wages paid. In fact, the firm receives subsidies that depend on the level of employment, effectively lowering the firm's marginal labour costs. Denoting total equilibrium subsidies by s_t^*, we find that $\frac{\partial s_t^*}{\partial K_1} = E(b_{(2)})$ and $\frac{\partial s_t^*}{\partial K_2} = -E(b_{(2)}) + 2E(b_{(3)})$. Therefore, when the firm increases K_j, her labour costs increase not simply by $L'(K_j) \cdot w$, but by an amount with wages "adjusted" by the marginal subsidies.

Having solved all the stages of the game, we can describe the sub-game perfect Nash equilibrium. In it, the firm commits in Stage 1 to (K_1^*, K_2^*), defined by the first-order conditions (1.3.9) and (1.3.10). In Stage 2, the regions bid until the price on the clock passes their valuation. The region with the highest private benefits wins the largest establishment and offers subsidies of $s_1^*(K_1, K_2) = (L^*(K_1) - L^*(K_2))b_{(2)} + L^*(K_2)b_{(3)}$. The region with the second-highest private benefits wins the smaller establishment, paying subsidies equal to $s_2^*(K_1, K_2) = L^*(K_2) \cdot b_{(3)}$. In Stage 3, the firm invests the amounts (K_1^*, K_2^*), employs labour $L(K_j)$ in each establishment j, and produces according to $f(\cdot)$.

1.3.4 Equilibrium Amount of Investment: Bidding War vs. No Bidding War

For comparison purposes, without a bidding war, the firm chooses to invest an equal amount of capital in two random regions. Indeed, the firm's revenues are then simply equal to $\pi_1(K_1) + \pi_2(K_2)$. The first-order conditions are

$$p \cdot \frac{\partial f(K_1, L(K_1))}{\partial K_1} = wL'(K_1) + r$$
$$p \cdot \frac{\partial f(K_2, L(K_2))}{\partial K_2} = wL'(K_2) + r$$

Put differently, the firm's optimal allocation in this case simply results from equating marginal revenues and marginal costs in each establishment. The assumptions on the production function imply that the firm chooses an identical investment in both plants: K_{nbw}.

Since the firm has no information about the private benefits of the regions, and since regions are identical in terms of productive capacity, the firm chooses to invest an equal amount K_{nbw} in two regions. She can just choose two regions at random, since her production costs and profits will be identical with any set of two regions.

This comparison begs the question whether the firm invests more in total when allocating through a bidding war than when she randomly chooses two regions to invest in. Intuitively, one might suspect that the firm always chooses a larger K_1 when using a bidding war, since "adjusted wages" are lower than w. We prove this intermediary result in the following lemma.

Lemma 1.2. *The capital investment in the first establishment (K_1) is always greater under a bidding war than without a bidding war.*

Proof. As long as $E(b_{(2)}) > 0$, adjusted wages (the firm pays wages w, but the subsidy effectively lowers them) are lower than w. Indeed, $w > w - E(b_{(2)})$. Therefore, $K_1^* > K_{nbw}$. ∎

The intuition is less clear in the case of the second establishment. Indeed, $E(b_{(2)}) - 2E(b_{(3)})$ could be greater or smaller than zero, depending on the distribution of the private benefits. In turn, investment could be lower or higher than without a bidding war. With a uniform distribution, it is easy to see that K_2^* will be greater than (with $n > 3$) or equal to (with $n = 3$) K_{nbw}. In the following lemma, we prove that the opposite is possible.

Lemma 1.3. *There exists some distribution of private benefits for which the firm invests less in the second establishment under a bidding war than under a situation without a bidding war.*

Proof. We prove this lemma by constructing an example. Take the following cumulative distribution function: $G(b) = b^{1/3}$ on the interval $[0, 1]$. With such a function, $E(b_{(2)}) = \frac{n(n-1)}{(n+2)(n+3)}$ and $E(b_{(3)}) = \frac{n(n-1)(n-2)n!}{(n+3)!}$. Consequently, $E(b_{(2)}) - 2E(b_{(3)}) > 0$ if and only if:

$$\frac{n+1}{n-2} > 2$$

$$n < 5$$

For this distribution function, if $n < 5$, we have $w + E(b_{(2)}) - 2E(b_{(3)}) > w$, and the firm has larger effective marginal labour costs in the second establishment than she would under a situation with no bidding war. Consequently, she chooses a level of K_2^* lower than the no-bidding-war amount ($K_2^* < K_{nbw}$). ■

This distribution function is strongly skewed to the right, giving more weight to values closer to zero. Therefore, for low values of n, $b_{(3)}$ is sufficiently close to the lower bound, and thus smaller than $b_{(2)}$, for the wage adjustment to be positive. In economic terms, such a distribution would translate in a situation where one or few regions put a great value on the firm's presence, while the great majority of regions put little to no value. In such a case, the firm might be able to extract a large subsidy from one government, but the differentiation comes at the cost of lower production in the second plant.

We are ultimately interested in the comparison of $K_1^* + K_2^*$ and $2 \cdot K_{nbw}$. From Lemma 1.2, we know that $K_1^* > K_{nbw}$, so for total investment to be lower under a bidding war, it is necessary that $K_2^* < K_{nbw}$ by an amount large enough to counter-balance the increase in the first establishment. Lemma 1.3 shows that it is possible that $K_2^* < K_{nbw}$.

We are unable to provide a general proof for a comparison of $K_1^* + K_2^*$ and $2 \cdot K_{nbw}$. However, we follow Haaparanta (1996) and prove it here for a specific functional form, namely a Cobbs-

Douglas production function. We show that in this case, the decrease in K_2 is never large enough to counter-balance the increase in K_1. In other words, total investment is always larger when using a bidding war than under the benchmark without a bidding war.

Proposition 1.2. *Assuming a Cobbs-Douglas production function with decreasing returns to scale ($\alpha + \beta < 1$), the total amount invested by the firm under a bidding war is always larger than the amount she would invest without a bidding war.*

Proof. The first-order condition for profit maximisation in one arbitrary establishment is:

$$p\frac{\partial f(K, L(K))}{\partial K} = L'(K)(w - x) + r \tag{1.3.11}$$

where x can be zero or the adjustment on marginal labour costs arising from subsidies. If $f(K, L) = K^\alpha L^\beta$, and using the function $L(K)$ as in equation (1.3.2), we find that:

$$\frac{p(\frac{p\beta}{w})^{\frac{\beta}{1-\beta}}(\frac{\alpha}{1-\beta}) \cdot K^{\frac{\alpha}{1-\beta}-1} - r}{(\frac{p\beta}{w})^{\frac{1}{1-\beta}}(\frac{\alpha}{1-\beta})K^{\frac{\alpha}{1-\beta}-1}} = w - x$$

This equation can be expressed as (with $A > 0$ and $B > 0$):

$$A - B \cdot K^{\frac{1-\alpha-\beta}{1-\beta}} = w - x \tag{1.3.12}$$

Since $0 < \frac{1-\alpha-\beta}{1-\beta} < 1$, Figure 1.1 illustrates a stylised version of the left-hand side of Equation (1.3.12).

In particular, since the second derivative is positive, a decrease in the right-hand side of a given amount (e) increases K by more than an identical increase in the right-hand side would decrease K. Since we know that $\left|E(b_{(2)}) - 2E(b_{(3)})\right| < \left|-E(b_{(2)})\right|$, the possible increase in the left-hand side (in the case of K_2) is always lower than the decrease in the left-hand side (in the case of K_1),[10] Therefore, we can conclude that the increase in K_1 due to a bidding war is always larger than the decrease in K_2. Consequently, the total amount invested is always larger in a bidding war, under specific assumptions on the production function. ■

This proposition implies that bidding wars actually increase the firm's total investment. Note that in the proof above, we made no assumption on the distribution of the regions' private benefits, other than they are always non-negative. While the proof was for a Cobbs-Douglas

[10] Or they are both decreases, in which case total investment is certainly increased

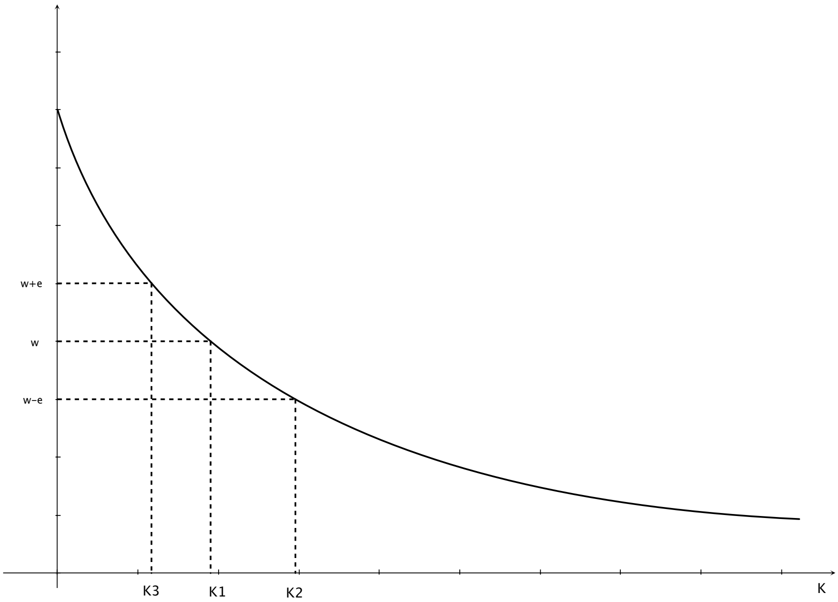


Figure 1.1: A stylised illustration comparing an upwards adjustment of wages to a downwards adjustment and their effects on the amount of capital invested.

function, the result should hold in many situations. In fact, Proposition 1.2 would be reversed only when two conditions are met: the distribution of private benefits respects Lemma 1.3 (so that $K_2^* < K_{nbw}$), and the production function has to be of a different shape than described in Proposition 1.2. Moreover, Proposition 1.2 does provide a general condition on the production function for which total investment increases. In particular, any function with a similar shape (first derivative negative, second derivative positive) for the left-hand side should provide the same result:

$$\frac{\partial}{\partial K}\left(\frac{p\frac{\partial f(K,L(K))}{\partial K} - r}{L'(K)}\right) < 0$$
$$\frac{\partial^2}{\partial K^2}\left(\frac{p\frac{\partial f(K,L(K))}{\partial K} - r}{L'(K)}\right) > 0$$

Are Regional Governments Better Off with a Bidding War?

Given the results above, one may wonder if it's in the regions' best interests that such a bidding war takes place. Without a bidding war, region i has the following expected utility:

$$E(W_{nbw,i}) = \frac{2}{n} L(K_{nbw}^*) \cdot b_i \tag{1.3.13}$$

where K_{nbw}^* is the investment from the firm in one establishment, without a bidding war.

With a bidding war, the same region has the following expected utility

$$E(W_{bw,i}) = \int_{\underline{b}}^{b_i} \int_{\underline{b}}^{b_{(1),-i}} (L(K_1^*)b_i - s_1^*)h(b_{(1),-i}, b_{(2),-i}, n-1)db_{(2),-i}db_{(1)} \\ + \int_{b_i}^{\overline{b}} \int_{\underline{b}}^{b_i} (L(K_2^*)b_i - s_2^*)h(b_{(1),-i}, b_{(2),-i}, n-1)db_{(2),-i}db_{(1),-i} \quad (1.3.14)$$

where for region i, $db_{(k),-i}$ is the $k-th$ highest benefit among the $n-1$ other regions. The expression $E(W_{nbw,i}) = E(W_{bw,i})$ defines a level of b_i over which a region prefers a bidding war. Conversely, it also defines a level of b_i under which regional governments are made worse off by a bidding war.

This preference results from 2 factors. First, with a bidding war, regions with large private benefits expect to win more often. Second, under a bidding war, the regions expect the firm to choose a higher level of capital K_1, and, as seen in the discussion on Proposition 1.2, a higher level of capital K_2 as well, at least in some cases.

To illustrate, with a Cobb-Douglas production function of parameters $\alpha = \beta = 1/3$, a uniform distribution of benefits on $[0, 1]$, and $p = w = r = 1$, to illustrate, we find that a given region i prefers that the firm uses a bidding war as long as

$$b_i > 0.227$$

1.3.5 A Numerical Example

To illustrate the results of the model, let's continue with the simple Cobbs-Douglas production function introduced previously: $f(K, L) = K^\alpha L^\beta$, with $\alpha + \beta < 1$. With specific functional forms, we can find the optimal investment allocation given a set of parameters $\{\alpha, \beta, p, w, r, n\}$ The analytical solutions are omitted here, as they are not informative. Instead, we describe graphically how the firm behaves facing different conditions.

One interesting question is whether the number of regions in the bidding war affects the firm's investment choices. In the more general model, note that when $E(b_{(2)})$ and $E(b_{(3)})$ are closer together, the differentiation between K_1 and K_2 diminishes. In the extreme case of $E(b_{(2)}) = E(b_{(3)})$, we have that $K_1^* = K_2^*$. In turn, the number of regions n participating in the bidding war affects the difference between $E(b_{(2)})$ and $E(b_{(3)})$. For example, if the distribution of private benefits is uniform on $[0, 1]$, then a low number of regions (e.g., 3 regions) will translate in a large difference between the expected private benefits of the regions, while a larger number of regions will translate in lower differences. For that reason, we should see decreasing differentiation with an increasing number of competitors. Figure 1.2 illustrates this relationship for specific values of the parameters and a uniform distribution. It also shows how both K_1^* and K_2^* are larger than K_{nbw}^*.

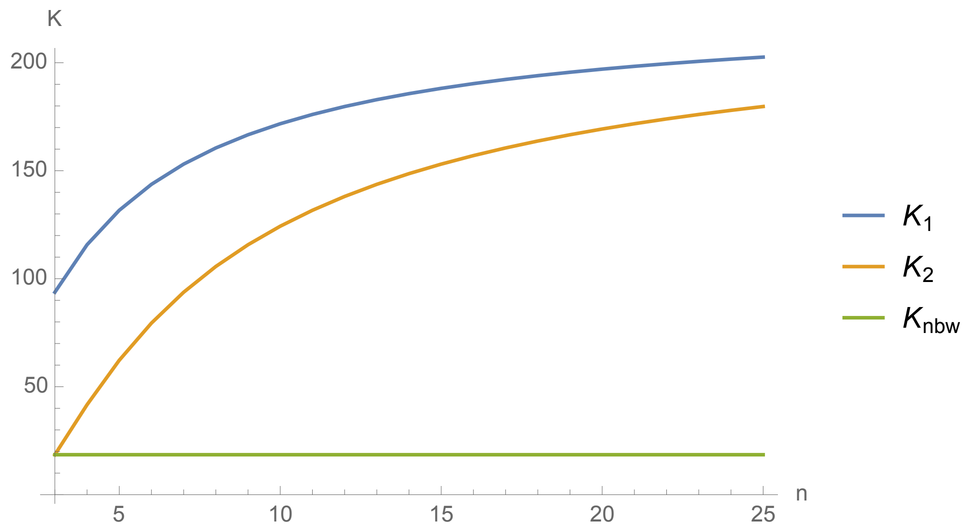


Figure 1.2: K_1 vs K_2, with a uniform distribution

Lemma 1.3 showed that for some distributions of the private benefits, the value of K_2 may behave differently. Figure 1.3 shows how K_1 and K_2 vary with n for the distribution $b^{\frac{1}{3}}$ on the interval $[0, 1]$, along with the value of K_{nbw} as reference. It shows how investment in the second establishment may actually be lower than without a bidding war, but that even in this example, *total* investment is higher.

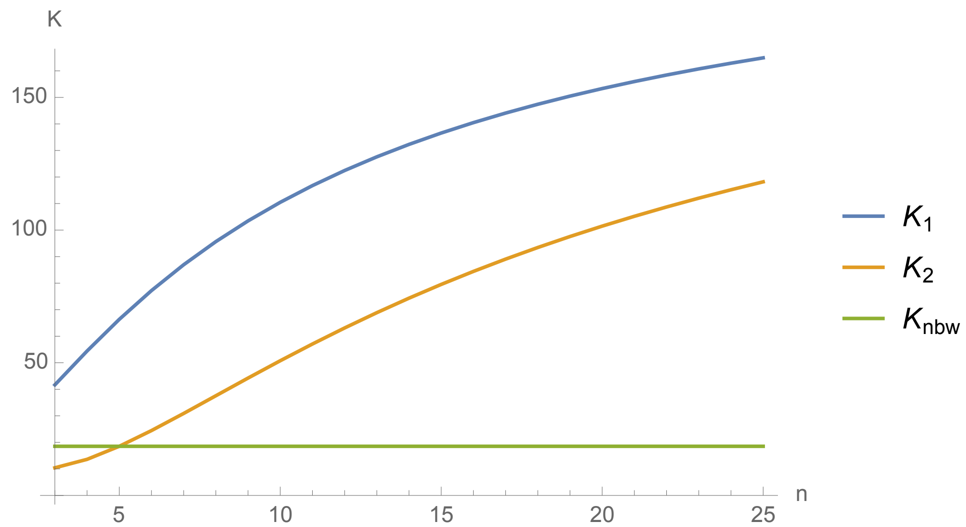


Figure 1.3: K_1 vs K_2, with distribution of private benefits respecting Lemma 1.3

1.4 Endogenous Plant Size: Comparison to a Single Plant Bidding War

The previous sections makes two additions to the usual discussion on bidding wars. First, the firm can choose the amount of capital to invest endogenously. Second, we consider the possibility for the firm to make multiple new investments. In this section, we aim to disentangle these two effects, investigating the endogenous investment decision of the firm when she is restricted to one plant. To that end, we consider the model, but restricted to only one new establishment. The set-up of the model is identical, except that the firm only decides on $K_1 = K_s$.

In this restricted model, the solution in Stage 3 is simple. The firm maximizes profits in her plant by choosing L, with a fixed K since it is chosen in Stage 1. Her maximization problem in the plant is as follows.

$$\max_{L} \quad pf(K^*, L) - wL - rK^* \tag{1.4.1}$$

The first-order condition is

$$pf'(K^*, L) - w = 0$$

This condition is standard, and defines the optimal choice of L given the amount of capital invested in the earlier stages. We define the function $L(K)$, determining the amount of labour employed for each possible equilibrium level of capital invested in the first stage.

At the auction stage, the equilibrium winning bid will be

$$s^*(K) = L(K_s) \cdot b_{(2)} \tag{1.4.2}$$

where $b_{(2)}$ is the second-highest private benefits among the n competing regions.

In the first stage, then, the firm's optimisation problem is the following:

$$\max_{K} \Pi = E(\pi(K) + s^*) = E\left[pf(K, L(K)) - wL(K) - rK + L(K) \cdot b_{(2)}\right] \tag{1.4.3}$$

where π and s^* are, respectively, the operating profits of the firm's plant and the equilibrium subsidy. The result of that problem leads to the following lemma.

Lemma 1.4. *A single bidding war for a new plant increases the firm's investment compared to a situation without a bidding war.*

Proof. The first-order condition is:

$$\frac{\partial E(\Pi)}{\partial K} = L'(K)E(b_{(2)}) + p(\frac{\partial f(K, L(K))}{\partial K} + \frac{\partial f(K, L(K))}{\partial L(K)} \cdot L'(K)) - wL'(K) - r = 0$$
$$\frac{\partial E(\Pi)}{\partial K} = L'(K)E(b_{(2)}) + p\frac{\partial f(K, L(K))}{\partial K} - wL'(K) - r = 0$$

It simplifies to

$$p\frac{\partial f(K, L(K))}{\partial K} = r + L'(K)(w - E(b_{(2)})) \tag{1.4.4}$$

The first-order condition is similar to the one for the largest establishment in the two-plant model. In particular, it implies that when using a bidding war, the firm chooses to invest an amount of capital K_s greater than would be invested without a bidding war. Indeed, the subsidies received effectively reduce the cost for the firm's labour ($w - E(b_{(2)}) < w$). ■

Therefore, even simply allowing the firm to choose the amount to invest already affects her investment decision. In fact, the first-order condition (equation 1.4.4) is exactly the same as that for the largest establishment in the two-plant model. In turn, the amount invested in the single plant is the same as that invested in that largest establishment. Note that in the two-plant problem, we had $s_1^*(K_1, K_2) = (L(K_1) - L(K_2))b_{(2)} + L(K_2)b_{(3)}$. Assuming $K_2 = 0$, the equilibrium subsidy for the first establishment reduces to $s_1^*(K_1, 0) = L(K_1)b_{(2)}$, which is exactly the value of subsidies found in the one-plant problem.

We thus find that a single bidding war already increases the firm's investment (when it is endogenous to the model) compared to a situation without a bidding war. Another question is whether the assumption that the firm conducts two *simultaneous* bidding wars further modifies the allocation of investment.

To see this, we compare our results of the multi-establishment bidding war to a firm investing in multiple plants, but with unrelated bidding wars. Instead of a multi-unit auction as in the previous model, the firm would essentially conduct one auction, then a second one, with regions acting as though the contests are independent of each other. Comparing the investment and subsidies in this set-up with the findings of the multi-establishment bidding war, we find that:

Proposition 1.3. *Total investment and subsidies are larger when a single-establishment bidding war is repeated than in a two-plant bidding war.*

Proof. Define $\check{K}_1$ and $\check{K}_2$ as the amounts of investment chosen by the firm in these two bidding wars. From Lemma 1.4, we already know the investment in the first establishment, $\check{K}_1 = K_s$.

The related bid is thus $s^*(\check{K}_1) = L(\check{K}_1) \cdot b_{(2)}$. To keep a similar environment in both models, we assume that the second bidding war will take place among the $n-1$ remaining regions. The region with the largest private benefits among the $n-1$ remaining regions is $b_{(2)}$, so $s^*(\check{K}_2) = L(\check{K}_2) \cdot b_{(3)}$. The firm will decide to invest $\check{K}_2$ according to the following condition:

$$p\frac{\partial f(K, L(K))}{\partial K} = r + L'(K)(w - E(b_{(3)})) \tag{1.4.5}$$

Since $b_{(3)} < b_{(2)}$, $\check{K}_2 < \check{K}_1$. As in the multi-unit auction model, the plants are differentiated.

We start by comparing $\check{K}_1 + \check{K}_2$ and $K_1^* + K_2^*$. First, we know that $K_1^* = \check{K}_1$. For the second establishments, we can compare the respective first-order conditions:

$$\begin{aligned} p\frac{\partial f(K_2^*, L(K_2^*))}{\partial K_2^*} &= r + L'(K_2^*)(w + E(b_{(2)}) - 2E(b_{(3)})) \\ p\frac{\partial f(\check{K}_2, L(\check{K}_2))}{\partial \check{K}_2} &= r + L'(\check{K}_2)(w - E(b_{(3)})) \end{aligned}$$

Since $E(b_{(2)}) - 2E(b_{(3)} > -E(b_{(3)}$, the second establishment is larger with unrelated bidding wars ($\check{K}_2 > K_2^*$), so total capital invested is larger ($\check{K}_1 + \check{K}_2 > K_1^* + K_2^*$).

Subsidies are also larger. From equations 1.3.3, 1.3.4, and 1.4.2:

$$\begin{aligned} L(\check{K}_1) \cdot E(b_{(2)}) + L(\check{K}_2) \cdot E(b_{(3)}) &> 2L(K_2^*) \cdot E(b_{(3)}) + E(b_{(2)})(L(K_1^*) - L(K_2^*)) \\ E(b_{(3)}) \left[L(\check{K}_2) - 2L(K_2^*)\right] &> E(b_{(2)}) \left[(L(K_1^*) - L(K_2^*)) - L(\check{K}_1)\right] \\ \frac{2L(K_2^*) - L(\check{K}_2)}{L(K_2^*)} &< \frac{E(b_{(2)})}{E(b_{(3)})} \\ \frac{L(\check{K}_2)}{L(K_2^*)} &> 2 - \frac{E(b_{(2)})}{E(b_{(3)})} \end{aligned}$$

Since $L(\check{K}_2) > L(K_2^*)$, the left-hand side is greater than 1, and since $E(b_{(2)}) > E(b_{(3)})$, the right-hand side is smaller than 1. The last line in the previous calculation is thus always true. Therefore, subsidies are larger when the firm conducts two unrelated bidding wars. ■

The assumptions in Proposition 1.3 may be unrealistic. When participating in the repeated bidding war of Proposition 1.3, regional governments may in fact expect that the firm will have multiple plants available, as we argued earlier. For that reason, a repeated bidding war is unreasonable in practice. However, it offers a good benchmark to compare the main model of this chapter, namely the multi-establishment bidding war, to previous contributions in the literature. Indeed, previous papers implicitly assumed that bidding wars are unrelated. What Proposition 1.3 suggests is that single-plant models may overestimate the size of subsidies over many bidding wars.

This setup is essentially equivalent to two firms running separate bidding wars, under the assumption of single-unit demand from the regions.[11] In previous papers in this literature, authors consider a firm auctioning a single plant. In effect, in these models, if a second firm ran a bidding war, that second bidding war would be unrelated to the first. A notable exception is Martin (1999). He assumes that firms in the same industry benefit from agglomeration economies. In a model of sequential auctions for establishments from 2 different firms, he finds that regions overbid in the first auction, expecting to have an advantage in the second period auction.

In our multi-establishment bidding war, we consider a different case, where there are no agglomeration economies, but where the bidding wars are related since they are conducted by the same firm. Like Martin (1999), we find that bids are higher for one of the establishments, but the reason for this phenomenon in our model is different. Instead of being due to agglomeration economies, it results from the differentiation by the firm of the two establishment available who expects it will increase subsidies.

Finally, note that the simultaneous vs. sequential nature of our multi-establishment bidding war is not important for our results. Indeed, in a sequential auction for two establishments, but where the regions know that both auctions are conducted by the same firm and are thus related, the regional governments would bid differently in the first auction. Indeed, they would take into account that they can also participate in the second auction.

To see how the bids are equivalent, note that the optimal bid in the first auction is derived from the indifference between winning K_1, and losing K_1 but winning K_2.

$$L(K_1)b_i - \beta_1 = L(K_2)b_i - s_2^*(K_1, K_2)$$

with β_1 the bid from region for K_1 that makes it indifferent between the 2. We find $\beta_1 = (L_1 - L_2)b_i + E(s_2^*(K_1, K_2))$, with $E(s_2^*) = L(K_2)E(b_{(3)})$. The equilibrium subsidy is thus $s_1^*(K_1, K_2) = (L_1 - L_2)b_{(2)} + E(s_2^*(K_1, K_2))$ since the bids are monotonically increasing in b_i. The expected value of total subsidies for the firm are therefore equal to $(L(K_1) - L(K_2))E(b_{(2)}) +$

[11] This assumption ensures some continuity with the previous sections.

$2L(K_2)E(b_{(3)})$, which is exactly the same as in the open ascending auction.

1.5 Optimal Mechanism

So far, this chapter considered that the firm allocated the plants using an open ascending auction. However, there could be other options available to the firm. Is the one in the model optimal? This section determines the optimal mechanism, comparing it to the open ascending auction.

1.5.1 Constrained Problem: Pre-Determined Investment Choices

First, we find the optimal mechanism when making the assumption that the firm previously chooses the values of K_1 and K_2, committing to them as in the model of previous sections. We have n regional governments, each willing to buy up to 1 unit of production from a firm. Each regional government i has a private valuation for each job created by the firm of b_i. The b_i are identically and independently distributed according to $g(\cdot)$ on the interval $[\underline{b}, \overline{b}]$. Define $b = (b_1, ..., b_n)$, $B_i = [\underline{b}, \overline{b}]$, and $B = \Pi_i B_i = [\underline{b}, \overline{b}]^n$. The firm has two units of production available, $j = 1, 2$. We define $x_i(b) = (x_{i,1}(b), x_{i,2}(b))$ as the allocation function vector, with $x_{i,j}(b) \in [0, 1]$. Then, the expected payoff to a regional government is equal to $V_i = x_{i,1}(b)L(K_1)b_i + x_{i,2}(b)L(K_2)b_i$, and the expected utility is:

$$EU_i(x_i, b, s_i) = \int_{B_{-i}} (x_{i,1}(b_i, b_{-i})L(K_1)b_i + x_{i,2}(b_i, b_{-i})L(K_2)b_i - s_i(b_i, b_{-i}))g_{-i}(b_{-i})db_{-i} \quad (1.5.1)$$

The firm wants to maximise

$$E(\Pi) = \pi_1(K_1) + \pi_2(K_2) + \sum_{i=1}^{n} \int_B s_i(b)g(b)db \quad (1.5.2)$$

She chooses (K_1, K_2) in a previous step, and then implements a mechanism to allocate these two plants while receiving subsidies $(s_i(b))$ from regional governments.

The firm's objective is to choose a mechanism to maximise her profits. By the revelation principle, we can restrict our attention to direct mechanism characterised by a set of functions $\{x_i(b), s_i(b)\}_{i=1,...n}$ where the x_i's reflect the allocation rule, the s_i's reflect the payment rule when b is the vector of types reported by the regions. Formally, the firm then solves the following problem:

$$\max_{x(b),s(b)} \quad \int_B \left(\sum_{i=1}^{n} s_i(b) + \sum_{j=1}^{2} \left(\pi(K_j) \sum_{i=1}^{n} x_{ij} \right) \right) g(b)db$$

$$\begin{aligned} s.t. \quad & EU_i(x_i, b_i, s_i) \geq EU_i(x_i, \tilde{b_i}, b_{-i}, s_i) \quad \forall i & ICC \\ & EU_i(x_i, b_i, s_i) \geq 0 \quad \forall i \forall j & IRC \\ & \sum_{i=1}^{n} x_{ij} \leq 1 \quad \forall j = 1, 2 & FC1 \\ & x_{ij}(b) \geq 0 & FC2 \\ & x_{i1}(b) + x_{i2}(b) \leq 1 & FC3 \end{aligned}$$

The Incentive Compatibility Constraint (ICC) states that it must be optimal for each region to report its true private benefits (b_i). The Individual Rationality Constraint (IRC) states that it must be optimal for each region to participate in the mechanism. The other three constraints are feasibility constraints. FC1 states that for each plant, the allocation probabilities for all regions must sum to one or less. FC2 states that these probabilities must be non-negative. FC3 states that regions can, at the equilibrium, receive only one plant. The solution to this optimisation problem leads to the following proposition.

Proposition 1.4. *Assume the firm first commits to the sale of* (K_1, K_2)*, and subsequently chooses a mechanism to allocate these two plants. The optimal mechanism results in the same allocation* ($x^*(b)$) *and subsidies* ($s^*(b)$) *as the multi-unit open ascending auction.*

Proof. The solution to this problem in general is due to Myerson (1981). The solution here will follow Morand (2000), constrained to unit demand.

The incentive compatibility constraint (ICC) states that regional governments must have incentives to state their true private benefits. It has to be satisfied locally. Using the envelope theorem, it must be that

$$\begin{aligned} \frac{dEU_i(x_i, b_i, s_i)}{db_i} &= \frac{\partial EU_i(x_i, \tilde{b_i}, s_i, b_i)}{\partial b_i}\Big|_{\tilde{b_i}=b_i} \\ &= \int_{B_{-i}} (x_{i1}(b)L(K_1) + x_{i2}(b)L(K_2))g_{-i}(b_{-i})db_{-i} \end{aligned} \tag{1.5.3}$$

Define the marginal probabilities as:

$$p_{i1}(x_i, b_i) = \int_{B_{-i}} x_{i1}(b) g_{-i}(b_{-i}) db_{-i}$$
$$p_{i2}(x_i, b_i) = \int_{B_{-i}} x_{i2}(b) g_{-i}(b_{-i}) db_{-i}$$
$$p_i = (p_{i1}, p_{i2})$$

With these, we can rewrite Equation 1.5.3 as

$$\frac{dEU_i(x_i, b_i, s_i)}{db_i} = p_{i1}(x_i, b_i) L(K_1) b_i + p_{i2}(x_i, b_i) L(K_2) b_i \quad \forall i \tag{1.5.4}$$

From Equation 1.5.4, we can find the expected utility of a regional government such that the incentive compatibility constraint is respected:

$$\begin{aligned}
\int_{\underline{b}}^{b_i} \frac{dEU_i(x_i, t, s_i)}{dt} dt &= \int_{\underline{b}}^{b_i} (p_{i1}(x_i, t) L(K_1) t + p_{i2}(x_i, t) L(K_2) t) dt \\
EU_i(x_i, b_i, s_i) - EU_i(x_i, \underline{b}, s_i) &= \int_{\underline{b}}^{b_i} (p_{i1}(x_i, t) L(K_1) t + p_{i2}(x_i, t) L(K_2) t) dt \\
EU_i(x_i, b_i, s_i) &= \int_{\underline{b}}^{b_i} (p_{i1}(x_i, t) L(K_1) t + p_{i2}(x_i, t) L(K_2) t) dt + EU_i(x_i, \underline{b}, s_i)
\end{aligned} \tag{1.5.5}$$

This expected utility is thus expressed in two terms. The first term depends on the marginal probabilities to win one of the production sites, while the second one is the expected utility of a regional government with the lowest private benefits ($\underline{b}$).

With the incentive compatibility constraint, we can also show that $p_{ij}(x_i, b_i)$ is non-decreasing $\forall i, j$. First, we can rewrite the expected utility of a region that announces private benefits $\tilde{b_i}$ when he actually has private benefits b_i, and conversely, as

$$EU_i(x_i, b_i, \tilde{b_i}, s_i) = EU_i(x_i, \tilde{b_i}, s_i) - (b_i - \tilde{b_i}) \left[L(K_1) p_{i1}(x_i, \tilde{b_i}) + L(K_2) p_{i2}(x_i, \tilde{b_i}) \right]$$
$$EU_i(x_i, \tilde{b_i}, b_i, s_i) = EU_i(x_i, b_i, s_i) - (\tilde{b_i} - b_i) \left[L(K_1) p_{i1}(x_i, b_i) + L(K_2) p_{i2}(x_i, b_i) \right]$$

From the incentive compatibility constraint, we thus have that

$$EU_i(x_i, b_i, s_i) \geq EU_i(x_i, \tilde{b_i}, s_i) - (b_i - \tilde{b_i}) \left[L(K_1)p_{i1}(x_i, \tilde{b_i}) + L(K_2)p_{i2}(x_i, \tilde{b_i}) \right]$$
$$EU_i(x_i, \tilde{b_i}, s_i) \geq EU_i(x_i, b_i, s_i) - (\tilde{b_i} - b_i) \left[L(K_1)p_{i1}(x_i, b_i) + L(K_2)p_{i2}(x_i, b_i) \right]$$

A few manipulations show that

$$EU_i(x_i, b_i, s_i) - EU_i(x_i, \tilde{b_i}, s_i) \geq (\tilde{b_i} - b_i) \left[L(K_1)p_{i1}(x_i, \tilde{b_i}) + L(K_2)p_{i2}(x_i, \tilde{b_i}) \right]$$
$$EU_i(x_i, b_i, s_i) - EU_i(x_i, \tilde{b_i}, s_i) \leq (\tilde{b_i} - b_i) \left[L(K_1)p_{i1}(x_i, b_i) + L(K_2)p_{i2}(x_i, b_i) \right]$$
$$(\tilde{b_i} - b_i) \left[L(K_1)p_{i1}(x_i, b_i) + L(K_2)p_{i2}(x_i, b_i) \right] \geq (\tilde{b_i} - b_i) \left[L(K_1)p_{i1}(x_i, \tilde{b_i}) + L(K_2)p_{i2}(x_i, \tilde{b_i}) \right]$$

Therefore, if $\tilde{b_i} > b_i$, $L(K_1)p_{i1}(x_i, b_i) + L(K_2)p_{i2}(x_i, b_i)$ is non-decreasing in b_i. Defining $L = (L(K_1), L(K_2))$, we can express this equation as $L \cdot p_i(x_i, b_i)$. With this property, we can also simplify the individual rationality constraint to a single one:

$$EU(x, \underline{b}, s) \geq 0 \tag{1.5.6}$$

The problem of the firm can now be simplified. From Equations (1.5.1) and (1.5.5), we know that

$$\int_{\underline{b}}^{b_i} (p_i(x_i, t)L)dt + EU_i(x_i, \underline{b}, s_i) = \int_{B_{-i}} (x_i(b_i, b_{-i})Lb_i - s_i(b_i, b_{-i}))g_{-i}(b_{-i})db_{-i}$$

Therefore,

$$
\begin{aligned}
E\Pi &= \int_B \sum_{i=1}^{n} s_i(b)g(b)db \\
&= \sum_{i=1}^{n} \left[\int_B b_i x_i(b) Lg(b)db - \int_{B_i} \int_{\underline{b}}^{b_i} \int_{B_{-i}} (x_i(t, b_{-i}) Lg_{-i}(b_{-i}) db_{-i} \cdot dt \cdot g(b_i) db_i - EU_i(x_i, \underline{b}, s_i) \right] \\
&= \sum_{i=1}^{n} \left[\int_B b_i x_i(b) Lg(b)db - EU_i(x_i, \underline{b}, s_i) \right] - \sum_{i=1}^{n} \left[\int_{\underline{b}}^{\bar{b}} \int_{t}^{\bar{b}} \int_{B_{-i}} (x_i(t, b_{-i}) Lg_{-i}(b_{-i}) db_{-i} \cdot g(b_i) db_i \cdot dt \right] \\
&= \sum_{i=1}^{n} \left[\int_B b_i x_i(b) Lg(b)db - EU_i(x_i, \underline{b}, s_i) \right] - \sum_{i=1}^{n} \left[\int_{\underline{b}}^{\bar{b}} \int_{B_{-i}} (x_i(t, b_{-i}) Lg_{-i}(b_{-i}) db_{-i} \cdot (1 - G(t)) \cdot dt \right] \\
&= \sum_{i=1}^{n} \left[\int_B b_i x_i(b) Lg(b)db - EU_i(x_i, \underline{b}, s_i) \right] - \sum_{i=1}^{n} \left[\int_{\underline{b}}^{\bar{b}} \int_{B_{-i}} (x_i(b_i, b_{-i}) Lg_{-i}(b_{-i}) db_{-i} \cdot (1 - G(b_i)) \cdot db_i \right] \\
&= \sum_{i=1}^{n} \left[\int_B b_i x_i(b) Lg(b)db - \int_B (x_i(b) Lg(b)db \frac{(1 - G(b_i))}{g_i(b_i)} \right] - \sum_{i=1}^{n} [EU_i(x_i, \underline{b}, s_i)] \\
&= \sum_{i=1}^{n} \left[\int_B (b_i - \frac{(1 - G(b_i))}{g_i(b_i)}) \cdot x_i(b) Lg(b)db - EU_i(x_i, \underline{b}, s_i) \right]
\end{aligned}
$$

Define the virtual benefits of region i as $\beta_i(b_i) = b_i - \frac{1-G(b_i)}{g(b_i)}$. We make the usual assumption that the distribution function is regular: $\beta_i(b_i)$ is increasing in b_i. We can write the firm's expected revenues as

$$\sum_i \int_B \beta_i(b_i) x_i(b) Lg(b)db \tag{1.5.7}$$

In doing so, we assume that at the optimum, $EU_i(x_i, \underline{b}, s_i) = 0$. From this assumption, and Equations (1.5.1) and (1.5.5), we then find:

$$
\begin{aligned}
EU_i(x_i, b_i, s_i) &= \int_{\underline{b}}^{b_i} p_i(x_i, t) Ldt \\
&= \int_{B_{-i}} \int_{\underline{b}}^{b_i} x_i(t, b_{-i} dt g_{-i}(b_{-i}) db_{-i} \\
&= \int_{B_{-i}} \left[b_i(x_i(b_i, b_{-i}))L - s_i(b_i, b_{-i}) \right] g_{-i}(b_{-i}) db_{-i}
\end{aligned}
$$

With this equation, we can express the equilibrium payments $s_i^*(b)$:

$$
\begin{aligned}
\int_B \left[b_i(x_i(b))L - s_i(b) \right] g(b)db &= \int_B \int_{\underline{b}}^{b_i} x_i(t, b_{-i}) dt g(b) db \\
\int_B s_i(b) g(b) db &= \int_B b_i(x_i(b)) Lg(b)db - \int_B \int_{\underline{b}}^{b_i} x_i(t, b_{-i}) dt g(b) db \\
s_i^*(b) &= b_i(x_i^*(b))L - \int_{\underline{b}}^{b_i} x_i^*(t, b_{-i}) dt
\end{aligned}
$$

Assuming $x^*(b)$ is the allocation function that solves the firm's problem, we can then find the optimal payment function $s_i^*(b)$:

$$s_i^*(b) = b_i x_i^*(b) \cdot L - \int_{\underline{b}}^{b_i} x_i^*(t, b_{-i}) L dt \tag{1.5.8}$$

The optimisation problem can therefore be expressed as follows. Let $x^*(b)$ be the solution to the following problem:

$$\begin{aligned}
\max_{x(b)} \quad & \sum_i \int_B \left[\beta_i(b_i) x_i(b) L + \sum_{j=1}^{2} \pi(K_j) x_{ij}(b) \right] g(b) db \\
s.t. \quad & EU_i(x_i, \underline{b}, s_i) = 0 \quad \forall i \\
& (\tilde{b_i} - b_i) \left[p_i(x_i, b_i) \cdot L \right] \geq (\tilde{b_i} - b_i) \left[p_i(x_i, \tilde{b_i}) \cdot L \right] \quad \forall b_i < \tilde{b_i} \\
& \sum_{i=1}^{n} x_{ij} \leq 1 \quad \forall j = 1, 2 \\
& x_{ij}(b) \geq 0 \quad \forall i, j \\
& x_{i1}(b) + x_{i2}(b) \leq 1 \quad \forall i
\end{aligned}$$

Let $s_i^*(b)$ be given by:

$$s_i^*(b) = b_i (x_i^*(b)) L - \int_{\underline{b}}^{b_i} x_i^*(t, b_{-i}) dt$$

Then, (x^*, t^*) is the optimal mechanism.

Similarly to standard problems in mechanism design, the optimal allocation function is deterministic: $x^*(b)$ takes value of 0 or 1. In particular, the firm will allocate the first production unit ($L(K_1)$) to the region with the highest virtual valuation (equivalently, to the one with highest private benefits), and the second one ($L(K_2)$) to the region with second-highest virtual valuation. Defining $b_{(k)}$ as the k-th highest private benefits, we thus have

$$x^*(b) = (x_1^*(b), x_2^*(b)) = \begin{cases} (1,0) & if \quad b = b_{(1)} \\ (0,1) & if \quad b = b_{(2)} \\ (0,0) & otherwise \end{cases} \tag{1.5.9}$$

The optimal payment rule depends on this allocation function. First note that the first term in $s_i^*(b)$ is simply the value to the region of hosting the firm. For the region hosting K_1, it is equal to $b_{(1)} L(K_1)$, while for the region hosting K_2 it is equal to $b_{(2)} L(K_2)$. The second term can be interpreted as the informational rent going to the regions. Define $z_{ij}(b_{-i})$ as the lowest value of private benefits that a region i can announce and still win establishment j. The integral in the second term then takes the following values:

$$\int_{\underline{b}}^{b_i} x_i^*(t,b_{-i})Ldt = \begin{cases} L(K_1)b_i - L(K_1)b_{(2)} + L(K_2)b_{(2)} - L(K_2)b_{(3)} & if \quad b_i > z_{i1}(b_{-i}) \\ L(K_2)b_i - L(K_2)b_{(3)} & if \quad z_{i1}(b_{-i}) > b_i > z_{i2}(b_{-i}) \\ 0 & otherwise \end{cases}$$

The first case warrants some discussion. If a region's private benefits are greater than $z_{i1}(b_{-i})$, such that they win the first establishment, we also need to take into account the fact that by winning the first establishment, that region also renounces to the smaller establishment. We can see this more clearly when developing the expression to integrate: $\int_{\underline{b}}^{b_i} x_i^*(t,b_{-i})Ldt = \int_{\underline{b}}^{b_i}(x_{i1}^*(t,b_{-i})L(K_1)+x_{i2}^*(t,b_{-i})L(K_2))dt$. When calculating the integral over the interval $[\underline{b}, b_i]$, we have to take into account that $x(b)$ takes non-null values not only over the interval in which the region wins the first establishment, but also over the interval over which the regions wins the second establishment. These results lead to the following payments

$$s_i^*(b) = \begin{cases} (L(K_1) - L(K_2))b_{(2)} + L(K_2)b_{(3)} & if \quad b_i > z_{i1}(b_{-i}) \\ L(K_2)b_{(3)} & if \quad z_{i1}(b_{-i}) > b_i > z_{i2}(b_{-i}) \\ 0 & otherwise \end{cases} \tag{1.5.10}$$

These are exactly the same payments found in the auction in the previous sections. Since that auction led to the same allocation and the same payments, we can conclude that the auction implemented the optimal mechanism (albeit without reserve prices), from the point of view of the firm. Moreover, we can see that the *ex ante* choice of K_1 and K_2 will be identical.

■

This proposition indicates that the open ascending auction chosen in the first part of the chapter is actually optimal from the firm's point of view. In other words, she can do no better, when committing to K_1 and K_2 beforehand, than the open ascending auction.

In the solution to the problem, we saw that the firm allocated the plants to the regions with the highest *virtual valuations*. In our model, the regions have information on their own benefits while the firm does not. In turn, they receive some informational rents (as seen by the payments). In setting the optimal mechanism, the firm tries to extract some of that rent. In fact, the firm could decide not to allocate the plant at all even if it is efficient to do so. Indeed, at some positive level of b_i, $\beta_i(b_i)$ can be negative. If all signals are such that $\beta_i(b_i)$ is negative, the firm maximises her objective function by not allocating the plants.

In fact, the optimal mechanism should also define reserve prices: threshold values of the regions' private benefits under which the firm would not allocate her plants. In a simpler model, the reserve prices would simply be defined by the level of private benefits under which the virtual valuation is negative, $b_r = \beta^{-1}(0)$. Indeed, if the revealed b_i's are all lower, then the objective function would also be negative, thus choosing not to allocate the units at all.

In our model, however, the reserve prices must take the technological profits into account. Indeed, by not allocating the plants, the firm actually reduces her own profits. The intuition is similar. The firm selects the regions to allocate the plant by choosing $x(b)$, and her payoff must be positive: $\pi(K_1) + \beta(b_{r1})L(K_1) > 0$ and $\pi(K_2) + \beta(b_{r2})L(K_2) > 0$.

With reserve prices, the optimal mechanism would differ from the open ascending auction of the previous sections. Therefore, we find the conditions under which the reserve prices are non-binding.

Lemma 1.5. *For $K_j \in [0, \overline{K}]$ $\forall j$ and $p > \underline{p}$, the reserve prices in the optimal mechanism are non-binding.*

Proof. If the private benefits revealed through the mechanism are equal to $\underline{b}$, the lowest possible level, the payoff to the firm must respect the following condition:

$$\pi(K_j) + \beta(\underline{b})L(K_j) = pf(K_j, L(K_j)) - L(K_j)(w - \beta(\underline{b})) - rK_j \geq 0$$

Notably, $K_j = 0$ respects this condition. Moreover, given the assumptions on the production function, we know that the slopes of $pf(K_j, L(K_j))$ and $L(K_j)(w - \beta(\underline{b})) + rK_j$ are positive. Therefore, two cases are possible at $K_j = \epsilon$ (i.e., an arbitrary small level of investment):

- The firm makes positive profits: $pf(K_j, L(K_j)) - L(K_j)(w - \beta(\underline{b})) - rK_j > 0$
- The firm does not make profit: $pf(K_j, L(K_j)) - L(K_j)(w - \beta(\underline{b})) - rK_j < 0$

In the second case, we can conclude that for any $K_j > \epsilon$, she never makes profits if the winning region has private benefits $\underline{b}$. In the first case, we can conclude that the firm will make positive profits up to a certain point $\overline{K}$ (where $pf(\overline{K}, L(\overline{K})) = L(\overline{K})(w - \beta(\underline{b})) + r\overline{K})$. Assuming that p is large enough, we are always in the first situation.

Under these assumptions, the firm always makes profits at $\underline{b}$. If the private benefits revealed in the mechanism are higher, she also necessarily makes profits. Indeed, a larger b implies a lower $w - \beta(\underline{b})$, and thus higher profits at the same level of capital invested and prices.

Therefore, even if the firm sets reserve prices, they would never affect the decision if the pre-determined K_j are always in the interval $[0, \overline{K}]$. ■

1.5.2 The Social Planner Problem

The previous discussion shows that the optimal mechanism (at least under some conditions on the price p and with the pre-determined $K_j \in [0, \overline{K}]\ \forall j$) is equivalent to the open ascending auction of the previous sections. An interesting question, then, is whether this mechanism is optimal in terms of social welfare. To investigate the social welfare question, we can replace the firm as the decision-maker by a social planner trying to find a mechanism to allocate K_1 and K_2 (decided ex ante) to maximise a social welfare function. Would the allocations and payments be the same? The set-up is similar to the one of Proposition 1.4. The differences is that the objective function considers not only the firm's welfare, but also that of the regions. It also considers the marginal cost or public funds (λ). We also assume that the social planner is uninformed about the regions' signals.[12]

$$
\begin{aligned}
\max_{x(b), s(b)} \quad & E(W) = \int_B \left[\alpha E(\Pi) + \gamma \sum_{i=1}^{n} EU_i - \lambda \sum_{i=1}^{n} s_i(b) \right] g(b) db \\
s.t. \quad & EU_i(x_i, b_i, s_i) \geq EU_i(x_i, \tilde{b_i}, b_{-i}, s_i) \quad \forall i && ICC \\
& EU_i(x_i, b_i, s_i) \geq 0 \quad \forall i \forall j && IRC \\
& \sum_{i=1}^{n} x_{ij} \leq 1 \quad \forall j = 1, 2 && FC1 \\
& x_{ij}(b) \geq 0 && FC2 \\
& x_{i1}(b) + x_{i2}(b) \leq 1 && FC3
\end{aligned}
$$

The values for α and γ are the social weights placed on the welfare of the firm and the regions, respectively, and they sum to one ($\alpha + \gamma = 1$). In this section, we assume that the firm

[12] If the social planner has perfect information, the problem is trivial. It allocates the plants to the regions that value them the most, with no payment.

chooses the amounts of capital to invest in a previous step, and that the mechanism is used to allocate these amounts. Therefore, $E(\Pi) = \pi(K_1)\sum_{i=1}^{n} x_{i1}(b) + \pi(K_2)\sum_{i=1}^{n} x_{i2}(b) + \sum_{i=1}^{n} s_i(b)$. Since the firm has no information to reveal, she does not appear in the incentive compatibility constraints.

Lemma 1.6. *For a given K_1 and K_2, an uninformed social planner would locate the plants in the same regions as the firm.*

Proof. We can simplify the objective function as such:

$$E(W) = \int_B \left[\gamma \sum_{i=1}^{n} (x_i(b) b_i L) + (\alpha - \gamma - \lambda) \sum_{i=1}^{n} s_i(b) + \alpha \sum_{j=1}^{2} x_{ij}(b) \cdot \pi(K_j) \right] g(b) db \qquad (1.5.11)$$

By using the same manipulations on the constraints as in the previous problem, we find that

$$E(W) = \sum_{i=1}^{n} \int_B \left[(\alpha - \lambda)(x_i(b) b_i L) - (\alpha - \gamma - \lambda)(x_i(b) L \frac{1 - G_i(b_i)}{g_i(b_i)}) + \alpha \sum_{j=1}^{2} x_{ij}(b) \cdot \pi(K_j) \right] g(b) db$$

$$E(W) = \sum_{i=1}^{n} \int_B \left[\left(b_i - \frac{\alpha - \gamma - \lambda}{\alpha - \lambda} \cdot \frac{1 - G_i(b_i)}{g_i(b_i)} \right) (\alpha - \lambda) x_i(b) L + \alpha \sum_{j=1}^{2} x_{ij}(b) \cdot \pi(K_j) \right] g(b) db$$

$$E(W) = \sum_{i=1}^{n} \int_B \left[\beta_i'(b_i)(\alpha - \lambda) x_i(b) L + \alpha \sum_{j=1}^{2} x_{ij}(b) \cdot \pi(K_j) \right] g(b) db$$

The function $\beta_i'(b_i)$ differs from $\beta_i(b_i)$ by the multiplication of the inverse of the hazard function by a combination of the model parameters. We make the assumption that $\alpha - \gamma \geq \lambda$, implying also that $\alpha \geq \lambda$, so that welfare is non-negative. Intuitively, from Equation 1.5.11, this assumption implies that for the transfers from the regions to the firm, the additional social weight placed on the firm versus the regions (i.e., $\alpha - \gamma$) is large enough to cover the marginal cost of public funds (λ).[13]

Notably, with these assumptions, the social planner chooses the same deterministic $x^*(b)$:

$$x^*(b) = (x_1^*(b), x_2^*(b)) = \begin{cases} (1,0) & if \quad b = b_{(1)} \\ (0,1) & if \quad b = b_{(2)} \\ (0,0) & otherwise \end{cases} \qquad (1.5.12)$$

[13]The assumption $\alpha - \gamma \geq \lambda$ has additional implications for the marginal cost of public funds. Indeed, if the weight placed on the firm and regions is the same ($\alpha = \gamma$), then if $\lambda > 0$, social welfare is negative. Conversely, if we allow $\alpha - \gamma < \lambda$, then the shape of $\beta_i'(b_i)$ is uncertain. For a uniform distribution, it is merely necessary that $\left|\frac{\alpha-\gamma-\lambda}{\alpha-\lambda}\right| \leq 1$, but this is not true in the general case.

■

While the allocation function may be the same as the firm, the social planner's optimal mechanism is not entirely identical to the firm's. Since $\frac{\alpha-\gamma-\lambda}{\alpha-\lambda} \leq 1$, then $\beta_i'(b_i) \geq \beta_i(b_i)\ \forall i$. We can see that this has implications for the reserve prices. In particular, the social planner allocates the plants more often.

As in the discussion on the optimal mechanism from the firm's viewpoint, we do not discuss reserve prices but the conditions under which the reserve prices are not binding. However, to illustrate how the reserve prices would change, we first look at an example. Abstracting from the technological profits, we would find the following b_r:

$$0 = \beta_i'(b_r'^*) \qquad\qquad 0 = \beta_i(b_r^*)$$

$$0 = \frac{\alpha-\gamma-\lambda}{\alpha-\lambda} \cdot \frac{1-G_i(b_r'^*)}{g_i(b_r'^*)} \qquad\qquad 0 = \frac{1-G_i(b_r^*)}{g_i(b_r^*)}$$

With a uniform distribution on $[0,1]$, for example,

$$b_r'^* = \frac{\alpha-\gamma-\lambda}{\alpha-\lambda} \cdot (1-b_r'^*) \qquad\qquad b_r^* = 1-b_r^*$$

$$b_r'^* = \frac{\frac{\alpha-\gamma-\lambda}{\alpha-\lambda}}{1+\frac{\alpha-\gamma-\lambda}{\alpha-\lambda}} < \frac{1}{2} \qquad\qquad b_r^* = \frac{1}{2}$$

Therefore, although the allocations under a social planner and the firm are the same, the social planner would allocate more often. We show now that this result translates in a looser condition on the possible investment interval ($[0, \overline{K}']$).

Proposition 1.5. *For any distribution such that* $\beta(\underline{b}) < 0$, $\overline{K}' > \overline{K}$. *In other words, the social planner allocates the plants more often.*

Proof. Similar to the firm's problem, we have that

$$\alpha\pi(K_j) + \beta'(\underline{b})(\alpha-\lambda)L(K_j) = \alpha p f(K_j, L(K_j)) - L(K_j)(\alpha w - (\alpha-\lambda)\beta'(\underline{b})) - \alpha r K_j \geq 0$$

Like in the firm's problem, if $K = 0$, then $\alpha\pi(K_j) + \beta'(\underline{b})(\alpha-\lambda)L(K_j) = 0$. Assuming that p is high enough so that with an arbitrary small amount of capital ϵ, $\alpha\pi(K_j) + \beta'(\underline{b})(\alpha-\lambda)L(K_j) > 0$, we want to find the maximum amount of investment such that profits are positive at the lowest level of private benefits $\underline{b}$.

$$\begin{aligned}
\alpha pf(\overline{K}', L(\overline{K}')) - L(\overline{K}')(\alpha w - (\alpha - \lambda)\beta'(\underline{b})) - \alpha r\overline{K}' &= 0 \\
\alpha \left[pf(\overline{K}', L(\overline{K}')) - L(\overline{K}')(w - \frac{\alpha - \lambda}{\alpha}\beta'(\underline{b})) - r\overline{K}' \right] &= 0 \\
\alpha \left[pf(\overline{K}', L(\overline{K}')) - L(\overline{K}')(w - (1 - \frac{\gamma + \lambda}{\alpha}\beta(\underline{b})) - r\overline{K}' \right] &= 0
\end{aligned}$$

In the third line, we used the definitions of $\beta'(\cdot)$ and $\beta(\cdot)$. This equation defines a level $\overline{K}'$. How does that amount differ from $\overline{K}$? The difference between the two conditions is in the multiplier in front of $L'(\cdot)$ (essentially the effective marginal cost of labour). We therefore compare these costs. $\overline{K}' > \overline{K}$ if and only if:

$$\begin{aligned}
w - \beta(\underline{b}) &> w - (1 - \frac{\gamma + \lambda}{\alpha}\beta(\underline{b})) \\
\beta(\underline{b}) &< 1 - \frac{\gamma + \lambda}{\alpha}\beta(\underline{b}) \\
\underline{b}\left(\frac{\lambda}{\alpha}\right) - \frac{1 - G(\underline{b})}{g(\underline{b})}\left(\frac{\gamma + \lambda}{\alpha}\right) &< 0 \\
\underline{b} - \frac{\gamma + \lambda}{\lambda}\frac{1 - G(\underline{b})}{g(\underline{b})} &< 0
\end{aligned}$$

This last expression will be true for low levels of $\underline{b}$. Notably, it is always true for $\underline{b} = 0$. However, more generally, we can prove that for any distribution $f(\cdot)$,

$$\underline{b} - \frac{1 - G(\underline{b})}{g(\underline{b})} < 0 \implies \underline{b} - \frac{\gamma + \lambda}{\lambda}\frac{1 - G(\underline{b})}{g(\underline{b})} < 0$$

Therefore, if the virtual valuation, from the firm's point of view, of a region with private benefits $\underline{b}$ is negative, then the social planner's condition is looser: $\overline{K}' > \overline{K}$. ■

The condition ($\beta(\underline{b}) < 0$) for this result is not very restrictive. Indeed, if from the firm's point of view, virtual valuations are all positive, the firm allocates all the time, so a discussion on welfare is not as interesting. Since it is inefficient socially to not allocate the plants, the looser conditions set by the social planner actually increases welfare. The intuition for this result is that the social planner puts less importance on the firm capturing the regions' informational rent.

1.5.3 Unconstrained Problem: Investment Choices Endogenous to the Mechanism

In the auction model and in the derivation of the optimal mechanism thus far, we have assumed that the firm commits to levels of capital investment (K_1, K_2). After the reveal of the private benefits, however, it is possible that the firm would like to modify her allocation of capital.

In this section, we investigate how the allocation and payments would differ under an unconstrained optimal mechanism, where the firm chooses the amounts to invest simultaneously with the allocation and payments. Also, we show that at least in expected values, the constrained optimal mechanism derived above leads to the same allocations as a more general, unconstrained mechanism.

To do so, we will modify the problem above slightly. Instead of only choosing a vector of probabilities $x_i(b)$, the firm chooses, in addition, a vector of investments $k_i(b) = (k_{i1}(b), k_{i2}(b))$. The firm's problem becomes:

$$
\begin{aligned}
\max_{x(b),k(b),s(b)} \quad & E(\Pi) = \sum_{i=1}^{n} \int_B \left[x_{i1}(b)\pi(k_{i1}(b)) + x_{i2}(b)\pi(k_{i2}(b)) + s_i(b)\right] g(b)db \\
s.t. \quad & EU_i(k_i, b_i, s_i) \geq EU_i(k_i, \tilde{b_i}, b_{-i}, s_i) \quad \forall i && ICC \\
& EU_i(k_i, b_i, s_i) \geq 0 \quad \forall i \forall j && IRC \\
& \sum_{i=1}^{n} x_{ij} \leq 1 \quad \forall j = 1, 2 && FC1 \\
& x_{ij}(b) \geq 0 && FC2 \\
& x_{i1}(b) + x_{i2}(b) \leq 1 && FC3 \\
& k_{ij}(b) \geq 0 && FC4
\end{aligned}
$$

By using similar manipulations on the constraints as in the constrained mechanism problem, we can transform the firm's objective function as such

$$
E(\Pi) = \sum_{i=1}^{n} \int_B \left[x_{i1}(b)\pi(k_{i1}(b)) + x_{i2}(b)\pi(k_{i2}(b)) + \beta_i(b_i)\left(x_{i1}(b)L(k_{i1}(b)) + x_{i2}(b)L(k_{i2}(b))\right)\right] g(b)db \tag{1.5.13}
$$

As in the previous sections, the solution for $x(b)$ is deterministic:

$$x^*(b) = (x^*_{i1}(b), x^*_{i2}(b)) = \begin{cases} (1,0) & if \quad b = b_{(1)} \\ (0,1) & if \quad b = b_{(2)} \\ (0,0) & otherwise \end{cases} \tag{1.5.14}$$

What are the values of $k^*_1(b)$ and $k^*_2(b)$? The firm will choose these investment amounts after observing the signals. She only commits to a function $k(b)$. From the objective function, we can find the first-order condition, assuming the b_i's are observed, and the plants are assigned to the respective winners.

$$p\frac{\partial f(k^*_1, L(k^*_1))}{\partial k^*_1} = L'(k^*_1)(w - \beta(b_{(1)})) + r$$
$$p\frac{\partial f(k^*_2, L(k^*_2))}{\partial k^*_2} = L'(k^*_2)(w - \beta(b_{(2)})) + r$$

These conditions define functions $k * (b)$.[14] The actual values of capital investment are not decided until the end of the mechanism. However, as long as $b_{(1)} \neq b_{(2)}$, $\beta(b_{(1)}) \neq \beta(b_{(2)})$. In turn, we can conclude that $k^*_1 \neq k^*_2$, just as in the constrained problem and in the auction model of the previous sections.

Obviously, since the firm does not commit to ex ante optimal values of investment, but chooses the amount only when observing the private benefits of the regions, the firm does better *ex post* in this unconstrained problem. However, on average, the constrained problem may lead, *ex ante* to the same solution.

Proposition 1.6. *If the regions' private benefits are uniformly distributed, then the constrained problem, on average, leads to the same amounts of investment from the firm.*

Proof. Assume that the b_i's are distributed uniformly on the interval $[0, \bar{b}]$. Then,

$$E(\beta(b_{(1)}) = E\left[b_{(1)} - (\bar{b} - (b_{(1)}))\right] = E[2b_{(1)} - \bar{b}] = \frac{n-1}{n+1}\bar{b} = E(b_{(2)})$$

[14]For this optimal mechanism, a discussion on reserve prices is unnecessary. Indeed, reserve prices will be endogenously determined in the $k^*(b)$ functions. The firm can simply set $k^*(b) = 0$ for some values of b, which is equivalent to a reserve price.

Similarly,

$$E(\beta(b_{(2)}) = E\left[b_{(2)} - (\bar{b} - (b_{(2)})\right] = E[2b_{(2)} - \bar{b}] = \frac{n-3}{n+1}\underline{b}$$

We also know that $E(b_{(3)}) = \frac{n-2}{n+1}\bar{b}$. Therefore,

$$-E(b_{(2)}) + 2E(b_{(3)}) = \frac{n-3}{n+1}\bar{b}$$

Consequently,

$$E(\beta(b_{(2)}) = -E(b_{(2)}) + 2E(b_{(3)})$$

Recall the first-order conditions from the auction model:

$$p\frac{\partial f(K_1, L(K_1))}{\partial K_1} = L'(K_1)(w - E(b_{(2)})) + r$$
$$p\frac{\partial f(K_2, L(K_2))}{\partial K_2} = L'(K_2)(w + E(b_{(2)}) - 2E(b_{(3)})) + r$$

On average, we thus have the exact same first-order conditions, leading to the same investment decisions from the firm. ■

The previous result holds for other distributions as well. This finding is not surprising. Indeed, virtual valuations can be interpreted as the marginal revenues on the sale for the seller. In the auction model, the "adjustments" on the marginal cost of labour, $E(b_{(2)})$ and $-E(b_{(2)}) + 2E(b_{(3)})$, are simply the marginal revenues from the subsidies. Similarly, $\beta(b_{(1)})$ and $\beta(b_{(2)})$ are the marginal revenues from the sale of the 2 investments to the seller in the unconstrained optimal mechanism.

1.6 Conclusion

This chapter investigates how a firm can allocate investment across multiple sites strategically to attract larger subsidies from regions who participate in a bidding war for these investments. It proposes a model in which a firm wishes to install new production facilities and puts regional governments in competition against each other to decide the location of those facilities. Regional governments submit bids, in the form of tax holidays or other financial packages, and the firm invests in the winning region(s). In contrast to previous models, the firm can split her production in two establishments. This split introduces new strategic choices for the firm, and modifies the bidding behaviour of the regional governments.

First, I find that equilibrium subsidies will depend on the firm's choice of capital amounts to invest. In particular, when she chooses asymmetric plants, total subsidies are larger. Second, I show that this bidding behaviour affects the optimal amounts of investment of the firm. More specifically, I find that she always chooses to differentiate her establishments. Therefore, the firm manipulates the bidding war, in order to attract larger subsidies. I then compare this result to a situation without a bidding war. I find that the effect of the bidding war is ambiguous in general, but when using a Cobbs-Douglas form for the production function, I find that total investment increases. Notably, this result is true for any distribution function. Moreover, total subsidies also increase.

I also discuss the optimal mechanism to allocate the establishments under three different sets of assumptions: first from the point of view of the firm, second from the point of view of a social planner, and finally under more relaxed assumptions on the firm's commitment. I find that the open ascending auction used in the model implements the optimal auction, under certain conditions. Moreover, I find that a social planner would optimally choose the same allocation and payment rules as the firm. Finally, I describe the optimal mechanism under the more general assumption that the firm chooses amounts to invest endogenously through the mechanism. I show that in expected value, this optimal mechanism without prior commitment from the firm results in the same *ex ante* allocation and payments.

To summarise, this chapter can be interpreted as two successive additions to the usual literature on bidding wars for firms. First, instead of considering a fixed investment amount, this chapter allows the firm to choose the amount of capital to invest and make available in a bidding war. This addition changes the strategy of the firm, inciting her to over-invest in comparison to a situation without a bidding war. Second, we add a multi-location component: the firm can allocate the total investment across two sites. This addition modifies the firm's behaviour further, by inciting her to differentiate the amounts of investment between the production sites. In doing so, she continues to over-invest in total.

In terms of social welfare, the chapter shows that while the allocation of investment is distorted versus a situation without a bidding war, the positive effect on allocative efficiency resulting from bidding wars is preserved in a multi-plant bidding war. More specifically, the regions that value the investment the most win it. However, while total investment is increased, which may have positive or negative implications, the increase is (under some conditions) for both hosts of the plants. Therefore, the increase in investment is not skewed only towards one of the winners at the expense of the other.

To conclude, the first chapter shows that the strategic behaviour of firms has important implications on the bidding wars for plants between regions. This distinction is important, since many bidding wars involve multi-nationals, and that such firms receive many subsidies in short periods by many local governments.

Chapter 2

Investment in Public Infrastructure and Regional Bidding Wars for Multi-Establishment Firms[1]

[1]This chapter was prepared in collaboration with Pierre-Henri Morand. I acknowledge the help of Thierry Madiès, who provided useful comments on this chapter, as well as Nicolas Gravel and Tanguy van Ypersele for helpful discussions and suggestions. This chapter also benefited from interactions at seminars at the University of Ottawa (Canada), the University of Macedonia (Thessaloniki, Greece), and the University of Fribourg (Switzerland).

2.1 Introduction

The previous chapter showed how bidding wars between regions can affect a firm's investment allocation across multiple sites. However, in addition to fiscal incentives, regional governments can also invest in business parks, road accesses, or other public infrastructure, thus hoping to make their territory more attractive to potential businesses. In fact, Davies (2005) lists a number of cases of subsidies to large plants where local governments offered road, sewer, and rail improvements as part of the incentives. Since the firm will only choose a subset of all regions in the bidding war, it is possible that some of that infrastructure spending is "wasted."

Jayet and Paty (2006) list some other examples from France where regions invested in "business areas," built to attract firms, suggesting that they were actually over-provided by regions (although actually socially optimal). Jayet and Paty (2006), however, consider many regions vying for a single mono-plant firm. The reality is that firms usually make several investment decisions in short amounts of time, such that these bidding wars are not necessarily independent.

The previous chapter has shown that when a firm allocates production across multiple establishments through a bidding war, its allocation is modified. Moreover, the production allocation of the firm certainly affects the amount of public infrastructure needed to host the firms' plants. Indeed, bigger plants may need more electricity, better road access, or access to a rail road, for example.[2] Therefore, the prior investment in infrastructure by the regions introduces a trade-off that was not present in the previous chapter: more differentiation can increase total subsidies, but may also reduce the number of regions participating in the bidding war. The objective of this chapter is to explore this trade-off, and analyse how it affects the allocation decision of the firm.

Our argument is as follows. When using a bidding war, the firm differentiates her establish-

[2]One specific example is the construction of data centres by companies like Google, Facebook, and Apple. In Reno (Nevada), Apple built a new data centre in 2012 based not only on tax incentives, but also likely due to the availability of energy in the region. At the time of the site's selection, the Reno Gazette Journal reported:

> Although energy costs are always a key consideration for any company looking to move or expand into an area, it's particularly important for power-hungry data centers, Donovan said. "They don't want just low-cost electric power but it also has to be reliable," Donovan said. "They also look at the source of that power and make sure that there is enough to support extra capacity without costs increasing dramatically if it's needed in the future." The site for the proposed data center—Reno Technology Park—currently has access to eight transmission lines as well as renewable energy sources, something that is always a key consideration for Apple. (http://www.rgj.com/story/money/reno-rebirth/2015/05/29/how-reno-landed-apple-one-of-the-biggest-prizes-in-the-data-center-industry/28181319/)

Note that at the time of the selection of Reno for a data centre, Apple had recently opened a similar plant in Oregon, and later opened another one in North Carolina.

ments, thus concentrating more production in one plant than without a bidding war. In turn, this concentration increases the size of one plant, and thus the infrastructure needed to host it. Consequently, some regions decide not to invest in the necessary infrastructure, and do not take part in the bidding war. Finally, this reduced competition for the firm's investment potentially reduces the subsidies she hopes to receive. At the extreme, only one region enters the bidding war, completely differentiating itself from the others, and can attract the firm without paying subsidies.

This paper contributes to the branch of the fiscal competition literature on bidding wars between regions to attract investment. It is especially related to the works of Taylor (1992), King et al. (1993), Justman et al. (2005), and Jayet and Paty (2006), who all introduce some sort of infrastructure investment from the regional governments. The main originality of this chapter in contrast to these studies is the consideration of a single firm who can build multiple new plants. In formal terms, we model this type of bidding war as a multi-unit auction with entry costs.

Taylor (1992) discusses the potential waste of such infrastructure races.[3] He builds a model in which jurisdictions compete for new firms by investing in new infrastructure, in a way that resembles an all-pay auction.[4] He finds that the investment race can potentially be wasteful, and that regions with a lower initial stock of infrastructure may be less willing to enter the competition. In this situation, infrastructure inequality between regions could rise over time. In his paper, the competition to attract firms only takes place through this infrastructure race; his model does not consider additional subsidies.

King, McAfee and Welling (1993) consider a two-period model with two countries, with a bidding war for a firm's investment in each period, and in which the firm can move in the second period. More closely related to the model of this chapter, they consider an extension in which regions can invest in infrastructure in a previous stage, thus increasing their productivity potential. They find that in equilibrium, regions tend to choose different levels of infrastructure, thus endogenously creating the productivity continuum described in their main model, with one country having more infrastructure and a higher pay-off.

Jayet and Paty (2006) build a model of competition between many regions to attract a single investment. In a first stage, regions must decide whether they want to develop a site

[3]The author notes that the investment can find some use, even in the case of a loss in the bidding war. For example, the road built to attract a firm can still be useful for motorists.

[4]In such an auction, all bidders pay the bid they offered, whether they win or lose.

to host the firm. They assume that regions must make at least part of that spending before the firm chooses a location, that spending is sunk, and it must be on a productive public good. They also assume that the firm has private information on her productivity in each region. This assumption greatly simplifies the analysis of the firm's problem: she can choose her site with full information. In this chapter, we make the inverse assumption: regions have more information (namely, on their own private benefits of hosting the firm). Jayet and Paty (2006) focus on the analysis of the regions' decision to develop sites or not, and the chosen tax rates. They find that even a social planner who knows that only one site will be occupied will choose to develop many sites. This result implies that over-provision of infrastructure is not necessarily bad from a social welfare point of view. Indeed, developing many sites increases the probability that the firm invests on one of the sites, instead of choosing an outside option.

This chapter is also related to the work of Justman et al. (2005). These authors consider a model consisting of many regions and many firms, but, like us, they are interested in the decision of regions to invest in infrastructure. They show that regions can use the tool of infrastructure to differentiate themselves by choosing a different type of infrastructure, thereby mitigating the direct competition with other regions. They also show that this differentiation is greater when regions are unable to distinguish the types of firms (i.e., with information asymmetry).

In a related paper, Justman et al. (2002) consider a model where infrastructure can also be differentiated by quality, thereby allowing regions to segment the market for their territory vertically. Some regions invest in higher quality infrastructure, attracting a subset of the firms for lower subsidies (or receiving taxes). The number of regions in this group is bounded according to the capability of the firms to take advantage of high-quality infrastructure. Remaining regions instead compete among each other using subsidies. In this chapter, we find a related result, albeit in a different context. Indeed, in a bidding war for a single firm, when regions can invest in infrastructure, it is possible for a region to differentiate itself, thus hosting the firm without paying subsidies.

Zissimos and Wooders (2008) also offer a similar model, in which firms have different public good requirements to produce, thus allowing regions to differentiate themselves. In this chapter, there is a single firm, but she can endogenously create differences in the infrastructure requirement of her plants.

The model developed in this chapter is related to the one of the previous chapter. However, to maintain tractability, we simplify the problem by setting an exogenous total amount of capital, thus only considering the *split* of the firm in the two establishments. We also simplify the definition of the firm's profits, by using a reduced form profit function instead. First, we show that the result of the previous chapter holds under a benchmark model: with a profit function that favours a maximum split of the firm's production (i.e., two identical establishments), a bidding war entices the firm to differentiate her plants.

Second, we show that when considering prior investment in infrastructure, it is possible even for a firm that would usually favour full concentration of production in a single establishment to split production across two sites. More generally, we show that the presence of infrastructure costs tends to reduce the firm's tendency to locate in one large establishment. This result highlights an interesting trade-off. While the firm wants to increase differentiation to benefit from larger subsidies, doing so increases the likelihood that firms exit the competition. At the extreme, only one region is adequate for the firm's production facility, and can win it without offering subsidies. Finally, we show for a uniform distribution of the regions' private benefits that while a bidding war might be less efficient than a social planner with full information, it is more efficient than an uninformed social planner. This result reflects the fact that the bidding war allocates the plants to the regions that value it the most.

The remainder of the paper is organised as follows. The next section presents the basic construction of the model, while Section 3 solves the benchmark model without infrastructure costs. In Section 4, we add endogenous entry to the model. Regional governments can decide, before the bidding war takes place, to invest in infrastructure (in other words, pay an entry cost for the auction). Section 5 discusses some implications of the model on social welfare. The last section concludes.

2.2 The Model

The players in this incomplete information game are the firm and the n regional governments indexed by $i \in 1, ..., n$. The firm wants to increase its production capacity, but is unsure of the optimal location for the new facilities. She may split her production in multiple locations, either in symmetric or asymmetric establishments. We will assume that the total investment is fixed at a certain exogenous amount, and that the firm chooses the proportion to allocate in each location. For simplicity and tractability, we limit the model to the case of two establishments, indexed by $j \in 1, 2$.

2.2.1 The Firm

The firm wants to invest a certain exogenous amount of capital K. She can invest in two establishments, choosing a production split $\vec{\alpha} = (\alpha_1, \alpha_2)$, where α_k is the proportion of production in establishment k. Since $\alpha_1 + \alpha_2 = 1$, we will set $\alpha_1 = \alpha$ and $\alpha_2 = 1 - \alpha$. Without loss of generality, we label the establishments such that $\frac{1}{2} \leqslant \alpha \leqslant 1$. In other words, the first establishment is the largest.

In each establishment, the firm's profits are a function of the amount of capital invested. In this chapter, we choose to use a simplified, reduced-form function for profits: $\pi(\alpha_k \cdot K)$. For simplicity, we normalize the exogenous quantity K to 1, so that profits only depend on the proportion of production in each establishment: $\pi(\alpha_k)$. We assume that this function is positive ($\pi(\alpha_k) > 0$) on the interval $[0, 1]$. The functional form of $\pi(\cdot)$ describes whether the firm benefits from concentration. The sign of the second derivative will be determinant for the analysis. If $\pi''(\cdot) > 0$, the firm inherently benefits from concentration, while $\pi''(\cdot) < 0$ implies that the firm inherently prefers multiple plants. To help understand that profit function, the following remark describes the behaviour of the firm without a bidding war.

Remark 2.1. *Assume the firm chooses production sites without a bidding war. If $\pi''(\cdot) < 0$, the firm chooses $\alpha = \frac{1}{2}$. If $\pi''(\cdot) > 0$, the firm chooses $\alpha = 1$.*

Proof. The firm's maximisation problem in the absence of a bidding war is simply

$$\max_{\alpha} \pi(\alpha) + \pi(1 - \alpha)$$

The first-order condition is

$$\pi'(\alpha) - \pi'(1 - \alpha) = 0$$

In words, the firm chooses α to equalize profits in both establishments: $\alpha = \frac{1}{2}$. First assume that $\pi''(\cdot) < 0$. Then, the second-order condition satisfies $\pi''(\alpha) + \pi''(1 - \alpha) < 0$, giving us a maximum. However, if $\pi''(\cdot) > 0$, then the second-order condition is positive, thus indicating that $\alpha = \frac{1}{2}$ is a minimum. In this case, we have a corner solution at $\alpha = 1$. ■

Without a bidding war, then, a firm with $\pi''(\cdot) < 0$ would choose to have two equally-sized establishments. In the opposite case ($\pi''(\cdot) > 0$), the firm would choose to produce in only one large establishment.

This profit function is essentially a reduced-form version of the one in the previous chapter. When $\pi''(\cdot) < 0$, it corresponds to the case where the firm's production function has a negative second derivative ($f''(k) < 0$). In this chapter, however, we are not interested in the amount of capital (which is fixed), but only its allocation across the two sites. With $\pi''(\cdot) < 0$, profits are maximised at $\alpha = \frac{1}{2}$, just like with $f''(k) < 0$, they are maximised at equal amounts of capital.

The firm's total *ex post* revenues are equal to

$$\Pi(\alpha) = s_1^* + s_2^* + \pi(\alpha) + \pi(1 - \alpha) \tag{2.2.1}$$

In other words, the total profits of the firm are equal to the sum of the two winning bids, and the operating profits in each establishment $\pi(\alpha_k)$, which themselves depend on the production split chosen by the firm. The objective of the firm is to maximise $\Pi(\alpha)$.

2.2.2 The Regions

Each of the $n > 2$ (symmetric) regional governments has private benefits of hosting the firm, b_i. These private benefits capture, for example, an increase in labor taxation from workers who will be employed by the firm, as well as spillovers to domestic firms, but also the compatibility of the firm for the region. Indeed, if the industry of the firm has a bad reputation in one region, the regional government would receive only small benefits from the firm's investment (due to, for example, re-election concerns). The signals are identically and independently distributed according to a distribution $f(\cdot)$ on some interval $\left[\underline{b}, \overline{b}\right]$ (with $\underline{b} \geq 0$). The *ex post* valuation of the region for establishment k is then equal to

$$V_{ik} = \alpha_k b_i - s_{ik} \tag{2.2.2}$$

where s_{ik} is the subsidy paid by region i (or the tax holiday offered by region i) for establishment k.

2.2.3 The Auction Process and Timing of the Game

The firm then conducts an auction (the bidding war), with both establishments available simultaneously. It is an open ascending auction. In particular, the firm runs an ascending clock, representing the current price for the lowest-value establishment still available (the one with the lowest proportion of production). Regional governments still in the auction are ready to offer a bid equal to the price currently on the clock. The winning bid is determined from the price on the clock when the previous bidder dropped from the auction. In this kind of auction, it is optimal for regional governments to drop from the auction when the value on the clock reaches their own valuation, $\alpha_k b_i$. The bid can be interpreted as a total "fiscal package" offered to the firm.[5] At the end of the auction, the two winning regions offer bids s_1^* (for establishment α_1) and s_2^* (for the second establishment), receive their respective parts of the firm's investment, and the firm produces its goods, incurring profits.

We can already see that there will be a difference between the symmetric and asymmetric cases. In the symmetric case, both establishments have the same value, so the winning bid is determined for both at the same time. In the asymmetric case, the two remaining regions will continue to compete once the value of the lowest subsidy is determined.

We can summarize the timing of the game as follows:

Stage 0: Nature picks the set of $\{b_i\}_{i=1,\dots,n}$. Regional governments learn their b_i.

Stage 1: The firm chooses and commits to an allocation of capital α, anticipating the subsidies offered by governments resulting from the auction in Stage 2.

Stage 2: The multi-unit auction takes place. Winning regions offer s_1^* and s_2^*.

Stage 3: The firm invests capital as determined in Stage 1 in the winning region(s), and receives profits.

2.3 Benchmark Model Without Costs in Infrastructure

We start by calculating the equilibrium in a simple benchmark model without infrastructure costs. In that case, all n regions enter the auction. We solve the model by backwards induction, to find the subgame-perfect Nash equilibrium. In the last stage, production takes place, and the firm's operating profits are simply determined by $\pi(\alpha) + \pi(1-\alpha)$.

2.3.1 Equilibrium subsidies

To calculate equilibrium bids, we first define the order statistics on the signals, $\{b_{(i)}\}_{i=1,\dots n}$, where $b_{(1)} > b_{(2)} > \dots > b_{(n)}$. Recall that every region has valuation $V_{ik} = \alpha_k b_i - s_i$. The following lemma describes the equilibrium subsidies:

[5] In effect, our model assumes that all regional governments have the same basic tax rate, but differentiate themselves with targeted tax holidays that may differ.

Lemma 2.1. *The equilibrium subsidies for the first and second establishments are equal to*

$$s_1^* = (2\alpha - 1)b_{(2)} + (1 - \alpha)b_{(3)} \tag{2.3.1}$$

$$s_2^* = (1 - \alpha)b_{(3)} \tag{2.3.2}$$

Proof. Regions stay in the auction only as long as their valuation is positive at the current price. In other words, $V_{ik} \geqslant 0$, and thus $\alpha_k b_i \geqslant s_i$. The highest bid that will be offered by region i for establishment k will be equal to $\alpha_k b_i$. As the clock price increases, regions gradually drop from the auction. The price s_2^* for the second establishment is determined when there are only two regions left in the bidding. Since the region with the third-highest signal will be the third-to-last to stop bidding, s_2^* will be equal to the value of the smallest establishment to that region:

$$s_2^* = (1 - \alpha)b_{(3)} \tag{2.3.3}$$

At this point, the remaining two regions will continue to bid until one of them exits to determine who among the two remaining bidders will receive the largest establishment. If the firm selected $\alpha = \frac{1}{2}$, the solution is easy: both remaining regions obtain one establishment for the same price (equal to s_2^*). However, by having asymmetric establishments, the firm can take advantage of the infra-marginal competition between the two remaining regions and increase the bid on the largest plant. The region with signal $b_{(2)}$ will leave first. To determine s_1^*, we calculate the bid at which that region is indifferent between the two establishments: $\alpha_1 b_{(2)} - s_1^* = \alpha_2 b_{(2)} - s_2^*$. From this point on, the region stops bidding because she receives a higher payoff by winning the small establishment. This leads to the following equilibrium bid:

$$s_1^* = (2\alpha - 1)b_{(2)} + (1 - \alpha)b_{(3)} \tag{2.3.4}$$

■

Note that if $\alpha = \frac{1}{2}$, the previous equation implies that $s_1^* = s_2^*$.

2.3.2 The Firm's Revenue Maximization Problem

As mentioned earlier, the firm wants to choose a production split $(\alpha, 1 - \alpha)$ to maximize the sum of the bids received for the establishments and her profits from production. She decides on that production split (α) before the auction takes place, committing to it.

Proposition 2.1. *With a bidding war, the firm always chooses $\alpha > \frac{1}{2}$.*

Proof. Recall that the firm's (ex-post) objective function is:

$$\Pi(\alpha) = s_1^* + s_2^* + \pi(\alpha_1) + \pi(\alpha_2)$$

The firm expects the equilibrium subsidies determined in Stage 2, and knows the distribution of the signals. Her expected revenues are thus equal to

$$E(\Pi) = \int_{\underline{b}}^{\bar{b}} \int_{\underline{b}}^{b_{(2)}} \Pi(\alpha) \cdot g_{2,3}(b_{(2)}, b_{(3)}, n) db_{(3)} db_{(2)} \tag{2.3.5}$$

where $g_{2,3}(b_{(2)}, b_{(3)}, n)$ is the joint distribution of the second and third-highest signals ($\underline{b} < b_{(3)} < b_{(2)} < \bar{b}$).[6] This distribution is equal to:

$$g_{2,3}(b_{(2)}, b_{(3)}, n) = n(n-1)(n-2) \cdot \Big[1 - F(b_{(2)})\Big] \Big[F(b_{(3)})\Big]^{n-3} f(b_{(2)}) f(b_{(3)})$$

We can use this expression in the equation for the expected revenues, obtaining:

$$\begin{aligned} E(\Pi) = \int_{\underline{b}}^{\bar{b}} \int_{\underline{b}}^{b_{(2)}} & \Big[(2\alpha - 1) b_{(2)} + 2(1-\alpha) b_{(3)} + \pi(\alpha) + \pi(1-\alpha)\Big] \cdot \\ & n(n-1)(n-2) \cdot \Big[1 - F(b_{(2)})\Big] \Big[F(b_{(3)})\Big]^{n-3} f(b_{(2)}) f(b_{(3)}) db_{(3)} db_{(2)} \end{aligned} \tag{2.3.6}$$

The firm chooses $\alpha \in [\frac{1}{2}, 1]$ to maximize this function. The interior solutions[7] can be described by the following first-order condition with respect to α:

$$\begin{aligned} \frac{\partial E(\Pi)}{\partial \alpha} = 0 = \int_{\underline{b}}^{\bar{b}} \int_{\underline{b}}^{b_{(2)}} & \Big[(2b_{(2)} - 2b_{(3)} + \pi'(\alpha) - \pi'(1-\alpha)\Big] \\ & \cdot n(n-1)(n-2) \cdot \Big[1 - F(b_{(2)})\Big] \Big[F(b_{(3)})\Big]^{n-3} f(b_{(2)}) f(b_{(3)}) db_{(3)} db_{(2)} \end{aligned} \tag{2.3.7}$$

The optimal value of α will therefore depend on the expected values of the signals, through

[6]In general, the joint distribution of two order statistics $j < k$ is equal to:

$$g_{j,k}(b_{(j)}, b_{(k)}, n) = \binom{n}{k} \binom{k}{j-1} \Big[1 - F(b_{(j)})\Big]^{j-1} \Big[F(b_{(j)}) - F(b_{(k)})\Big]^{k-1-j} F(b_{(k)})^{n-k} f(b_{(j)}) f(b_{(k)})$$

where $F(\cdot)$ is the cumulative distribution of the signals.

[7]On the $]0, \infty[$ interval, we assume $\pi(\cdot)$ and $F(\cdot)$ are continuous and twice differentiable. Therefore, $E(\Pi)$ is well-behaved. It is possible that we find a find extrema outside the $[\frac{1}{2}, 1]$ range. In that case, we'd have a corner solution at $\alpha = \frac{1}{2}$ or $\alpha = 1$. However, we can still describe the extremum, and subsequently find if it lies inside or outside the range.

the probability distribution function $f(\cdot)$, and on the functional form for the profits. We can simplify the first-order condition as such:

$$\begin{aligned}\pi'(1-\alpha)-\pi'(\alpha) = & \frac{2\int_{\underline{b}}^{\bar{b}}\int_{\underline{b}}^{b_{(2)}}(b_{(2)}-b_{(3)})\left[1-F(b_{(2)})\right]\left[F(b_{(3)})\right]^{n-3}f(b_{(2)})f(b_{(3)})db_{(3)}db_{(2)}}{\int_{\underline{b}}^{\bar{b}}\int_{\underline{b}}^{b_{(2)}}\left[1-F(b_{(2)})\right]\left[F(b_{(3)})\right]^{n-3}f(b_{(2)})f(b_{(3)})db_{(3)}db_{(2)}} \\ = & \; 2E(b_{(2)}-b_{(3)})=B \qquad (2.3.8)\end{aligned}$$

From the definition of order statistics, we know that B is always positive, so the FOC implies

$$\pi'(1-\alpha)>\pi'(\alpha)$$

This inequality has different implications depending on the sign of the second derivative of $\pi(\cdot)$. First, assume that $\pi''(\cdot)>0$. In that case, the second-order condition

$$\begin{aligned}\frac{\partial E(\Pi)^2}{\partial^2\alpha} = & \int_{\underline{b}}^{\bar{b}}\int_{\underline{b}}^{b2}(n-2)(n-1)n\left[1-F(b2)\right]F(b3)^{n-3}f(b_{(2)})f(b_{(3)})\left(\pi''(1-\alpha)+\pi''(\alpha)\right)db_{(3)}db_{(2)} \\ = & \; \pi''(1-\alpha)+\pi''(\alpha) \qquad (2.3.9)\end{aligned}$$

is always positive, implying that the first-order condition describes a minimum. Furthermore, the inequality $\pi'(1-\alpha)>\pi'(\alpha)$ along with the fact that $\pi''(\cdot)>0$ implies that the minimum α_0 is:

$$\begin{aligned}1-\alpha_0 &> \alpha_0 \\ \alpha_0 &< \frac{1}{2}\end{aligned}$$

Therefore, $E(\Pi)$ has a minimum at α_0 smaller than $\frac{1}{2}$. In that case, we know that the optimal split of the firm is to concentrate all production in one location, choosing $\alpha^*=1$.

If $\pi''(\cdot)<0$ instead, the second derivative of expected revenues is negative ($\frac{\partial E(\Pi)^2}{\partial^2\alpha}<0$). In that case, the first-order condition describes a maximum. As in the previous case, we can describe the optimal α_0 as such:

$$\begin{aligned}1-\alpha_0 &< \alpha_0 \\ \alpha_0 &> \frac{1}{2}\end{aligned}$$

Therefore, $E(\Pi)$ has a maximum at α_0 strictly greater than $\frac{1}{2}$, so the firm will choose α^* in the interval $]\frac{1}{2}, 1]$. In other words, in these conditions, the firm always either differentiate her establishments or concentrates all production in one location. ■

This result highlights the role of the auction in the firm's decision process. Without it, in the case that $\pi''(\cdot) < 0$,[8] she would always split in two symmetrical establishments. With the auction, she differentiates her production sites, or, in extreme cases, decides to have a single establishment ($\alpha^* = 1$).

The firm only modifies her allocation when it is already optimal, technologically, to split in multiple locations (i.e., $\pi''(\alpha) < 0$). In that case, the distortion from the bidding war, or the extent to which the firm modifies her allocation from symmetric establishments, depends on the difference between $\pi'(1-\alpha)$ and $\pi'(\alpha)$ at the equilibrium. This distortion resulting from the bidding war is increasing in $E[b_{(2)} - b_{(3)}]$. Put differently, as the firm expects a greater difference between the regions' signals, she increases the differentiation between her establishments. Intuitively, the firm expects that the bid for the large establishment will increase by an amount more than large enough to compensate for the reduction in the value of, and thus the subsidy for, the second establishment. In doing so, she expects an increase in her total profits (including subsidies). This result show how by running a bidding war, infra-marginal competition between the last two remaining bidders can increase total subsidies, as in Chapter 1.

Also as in Chapter 1, this benchmark model has the following subgame-perfect Nash equilibrium. In Stage 1, the firm commits to $\alpha > \frac{1}{2}$, depending on the sign of $\pi''(\cdot) > 0$, and anticipating the subsidies offered by the regions. In Stage 2, the regions bid until the subsidy on the clock passes their valuation. The region with highest private benefits wins the largest establishment and pays $s_1^* = (2\alpha - 1)b_{(2)} + (1-\alpha)b_{(3)}$. The region with second-highest private benefits wins the smaller establishment and pays $s_2^* = (1-\alpha)b_{(3)}$. In Stage 3, the firm receives profits from both establishments.

An interesting corollary of this proposition follows from how the first-order condition depends on n, and how the distortion of the firm's allocation changes with n. Intuitively, we anticipate that the expected value of the difference between the second- and third-highest signal will decrease with n. Indeed, as we take a greater number of draws from a bounded distribution, intuitively we'd expect the higher draws to be closer to the higher bound. Such a result would

[8] If $\pi''(\cdot) > 0$, the auction does not affect the firm's behaviour.

be difficult to prove in the general sense. We prove it here for the uniform distribution.

Corollary 2.1. *Suppose that the regions' signals are distributed uniformly on $[\underline{b}, \overline{b}]$. The distortion in the firm's location decision arising from the auction decreases with n, such that the firm chooses a split closer to the symmetrical split.*

Proof. Assume the private benefits are distributed according to a uniform distribution on $[\underline{b}, \overline{b}]$. Then, we know that (by using $F(x) = \frac{x-\underline{b}}{\overline{b}-\underline{b}}$):

$$\begin{aligned} B = & \quad 2E(b_{(2)} - b_{(3)}) \\ = & \quad \frac{2(\overline{b} - \underline{b})}{n+1} \end{aligned}$$

Taking the limit of the last expression as n approaches infinity, we see that $2E(b_{(2)} - b_{(3)})$ goes to zero. In other words, the distortion disappears, and the firm would act the same with and without an auction. Perhaps more interesting than what happens at very large n, however, is the behaviour of the distortion as n increases. The relation between B and n is not linear, although an increase in n always leads to a decrease in B. More formally, the first derivative of B with respect to n is equal to

$$\frac{\partial B}{\partial n} = \frac{2(\underline{b} - \overline{b})}{(n+1)^2}$$

which is always negative. In other words, as n increases, the distortion from the auction decreases, thus reducing the difference between $\pi'(1-\alpha)$ and $\pi'(\alpha)$. ■

This result actually holds for distributions other than the uniform. One important condition is that as n increases, the order statistics $b_{(2)}$ and $b_{(3)}$ move closer together. Even very skewed distributions, such as a χ^2 $(k = 3)$, satisfy such a condition.

2.3.3 A Numerical Illustration

As a simple but practical form for $\pi(\alpha_k)$, assume that the profits are simply equal to an exogenous parameter π multiplied by a function $h(\alpha_k)$ of the share of production in that establishment:

$$\pi(\alpha_k) = \pi \cdot h(\alpha_k)$$

The parameter π captures the potential profits of the firm, which does not depend on how she allocates capital. and its functional form describes the marginal returns to concentration. In the simplest case, $h(\alpha) = \alpha$ and the firm is always indifferent between producing in one place or two. A flexible functional form for that function is $h(\alpha, \lambda) = \alpha^{\lambda}$, where λ determines the sign of the second derivative of $\pi(\cdot)$. If $\lambda < 1$, $\pi''(\cdot) < 0$, while $\lambda > 1$ implies that $\pi''(\cdot) > 0$. If $\lambda = 1$, we have the simple function $h(\alpha) = \alpha$.

First, assume $\lambda = 2$, so that the firm benefits from concentrating its production. With this value for λ, we obtain a single extremum at:

$$\alpha_0 = \frac{1}{2} - \frac{1}{2(1+n)\pi}$$

Since the second derivative is positive, we know that it is a minimum. We also see that it is always lower than $\frac{1}{2}$, so revenues are always increasing between $\alpha = \frac{1}{2}$ and $\alpha = 1$. With $\lambda = 2$, we thus find that the firm optimally concentrates its whole production in the largest establishment ($\alpha^* = 1$).

If instead we assume that $\lambda = \frac{1}{2}$, solving the first order condition gives us:

$$\alpha^* = \frac{1}{16}\left(8 + \sqrt{64 - 2(1+n)^2\pi^2\left(8 + (1+n)\pi\left(\pi + n\pi - \sqrt{16 + (1+n)^2\pi^2}\right)\right)}\right)$$

As shown above, the first-order condition describes a maximum. As a numerical example, taking $n = 3$ and $\pi = 1$, we obtain $\alpha^* \approx 0.78$.

To give a more general idea of the relation between the optimal values of α and different values of λ, we can calculate α^* for all λ, using some value of n and π. Figure 2.1 illustrates a stylized version of that relation for $n = 3$ and $\pi = 1$. Unsurprisingly, for $\lambda > 1$, the firm always concentrates in a single establishment. For values of λ below 1, however, the firm never splits in two equal establishments. The shape of the curve for $\lambda < 1$ obviously depends on the functional forms chosen in solving the problem. However, it will be interesting to compare the shape of that curve with the one obtained in the more complete model that includes infrastructure costs (solved with the same functional form).

2.4 Endogenous Entry: Prior Investment in Infrastructure

We now turn to the more complete model, by introducing endogenous entry choice. We'll assume that regions must make some investment before they can be considered as a potential host region by the firm. In terms of auction theory, this investment corresponds to an entry cost. In our

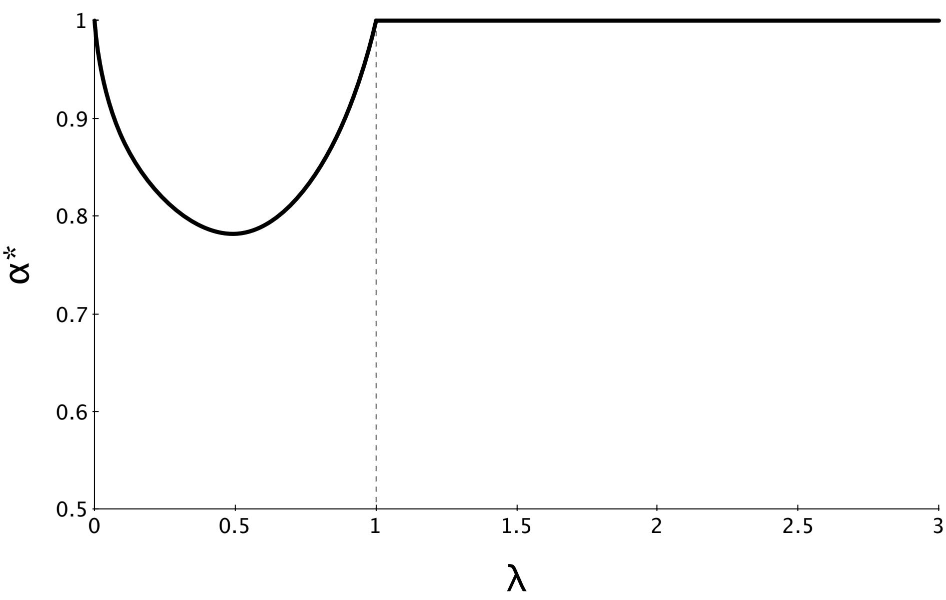


Figure 2.1: Optimal investment split of the firm (α) given λ

model, regions learn their signals b_i before making their entry decision. They also know the production split chosen by the firm. In this section, we assume that $\pi(\alpha) = \pi \cdot h(\alpha) = \pi \cdot \alpha^{\lambda}$ to keep the model tractable. In the simple model, we saw that the value of λ determined whether the firm, without a bidding war, preferred to concentrate all production ($\lambda > 1$) or to split in multiple establishments ($\lambda < 1$). We also assume that the regions' signals are distributed uniformly on $[0, 1]$.

The regions all have the same initial level of infrastructure, which is sufficient to host the smaller establishment. In other words, it is sufficient for establishments of sizes up to $\frac{1}{2}$. However, if they also want to compete for the larger establishment, they need to make additional investment in infrastructure, which increases with α (in other words, larger establishments require more infrastructure).[9] This investment in infrastructure is sunk once paid. While it may serve a purpose in later periods that are not considered here, in the model, it only serves to attract the firm. In other words, the infrastructure costs in the model only represent the part of infrastructure spending that is non-transferable. To solve the model, we propose a flexible

[9]Setting additional infrastructure needed for the small establishment to zero is basically equivalent to a standardization of the infrastructure level. Indeed, if they were greater than zero but still equal for everyone, it could reduce the total number of regions competing, thus changing the exact solution of the model, but we suspect that it would not change our discussion, or the main findings of our paper. Another more interesting extension would consider regions that have different initial levels of infrastructure. In this case, some regions may already reach the level needed for the large establishment, thus removing infrastructure costs for them. We leave this possibility for future research.

functional form for the infrastructure costs:

$$c(\alpha) = d \cdot (\alpha - \frac{1}{2})^2 \tag{2.4.1}$$

This function captures the fact that infrastructure costs should increase with α. In particular, this function assumes that they increase quadratically: slower for lower production, and increasingly faster as the establishment becomes larger. Infrastructure costs are also null when the firm splits in two equal establishments ($\alpha = \frac{1}{2}$). The parameter d captures the magnitude of the costs.

This entry decision modifies the timing of the model, by adding another stage:

Stage 0: Nature picks the set of $\{b_i\}_{i=1,\ldots,n}$. Regional governments learn their b_i.

Stage 1: The firm chooses and commits to an allocation of capital α, anticipating entry decisions and the subsidies offered by governments resulting from the auction in Stage 3.

Stage 2: The regions decide whether they want to be considered for the large establishment. If so, they pay the infrastructure cost $c(\alpha)$.

Stage 3: The multi-unit auction takes place. Winning regions offer s_1^* and s_2^*.

Stage 4: The firm invests capital, as determined in Stage 1, in the winning region(s).

As in the previous section, we solve the model by backwards induction.

By adding an endogenous entry decision, we also add the possibility that no region will wish to participate in the auction for the large establishment. In that case, we need to consider the possible courses of action for the firm. Figure 2.2 shows the different possibilities. After infrastructure costs are made (or not), a certain number of regions m are in the competition for the largest establishment, while all $n > 3$ regions are competing for the smaller establishment.

If $m = 0$, and no regions pay the infrastructure cost, then, if she decides to not change anything, the firm will only invest a total of $1 - \alpha$. She can obviously do better. In particular, she can renege on her previous commitment, and change her allocation to $\alpha = \frac{1}{2}$, ensuring every region participates in the bidding war, and allocating the entire amount of capital she wanted to. This modified auction using $\alpha = \frac{1}{2}$ is labeled as Stage 3′ in Figure 2.2. Obviously, the regional governments expect this possibility, and will consider it when choosing to enter or

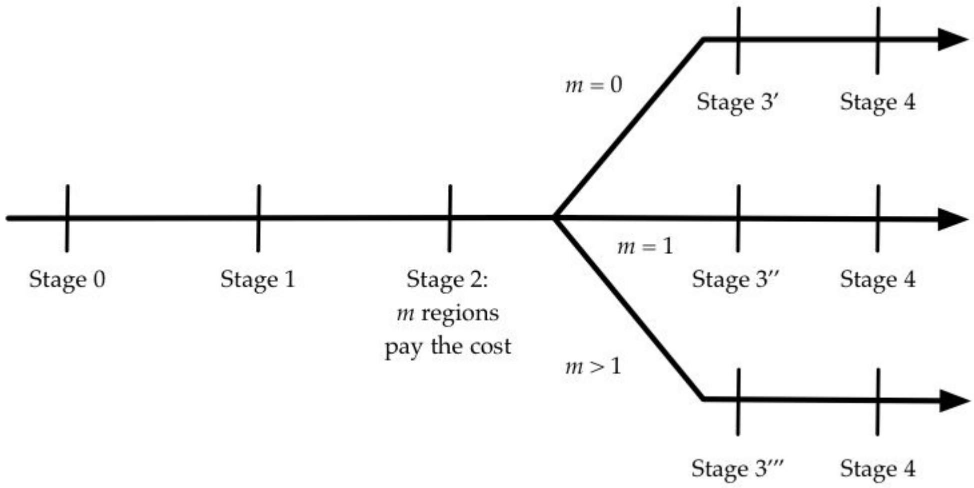


Figure 2.2: Timing with different number of entries

not.[10]

If $m = 1$, then only one region is suitable for the large investment of the firm, and that region can "win" that investment without further subsidies. In this case, the auction can carry on, but equilibrium subsidies will have to take into account the nature of the competition for the large establishment. This scenario is considered in Stage $3''$ of Figure 2.2.

If $m > 1$, then there are enough participants in the bidding war and the auction takes place as in the previous section, although only 2 regions will be able to bid for the large establishment. This scenario is considered in Stage $3'''$ of Figure 2.2.

2.4.1 Bidding Behaviour

First assume that there are $n = 3$ regions.[11] We start by describing the winning bids, taking entry decisions as given. After infrastructure costs are made (or not), a certain number of regions m are in the competition for the largest establishment, while all n regions are competing for the smaller establishment. The equilibrium bids will be similar to the ones in the simple model of the previous section, although some special cases exist. Table 2.1 summarises the possibilities

[10]We could also solve the model assuming that the firm makes the investment in infrastructure herself (i.e., installation costs). We could also imagine that the firm endogenously chooses a $\hat{\alpha}$ when faced with such a case. Alternatively, the firm could cancel the auction and restart the whole process, choosing a slightly lower α using the new information she gained from the non-entry decisions, repeating this process until at least one region participates. In all cases, the regions must anticipate that behaviour by the firm. We leave a complete discussion of dynamic or multi-period models for future research.

[11]As will be clear in the following paragraphs, additional regions would act exactly like the third.

for the bids.

Table 2.1: Possible Cases for the Winning Bids

Number of regions incurring infrastructure cost	s_1^*	s_2^*
0	$\frac{1}{2}b_{(3)}$	$\frac{1}{2}b_{(3)}$
1	0	$(1-\alpha)b_{(3)}$
2	$(2\alpha-1)b_{(2)}+(1-\alpha)b_{(3)}$	$(1-\alpha)b_{(3)}$
3	$(2\alpha-1)b_{(2)}+(1-\alpha)b_{(3)}$	$(1-\alpha)b_{(3)}$

First, if $m = 0$, then there is no region with the infrastructure required to host the large establishment. As explained above, we assume that, when faced with no demand for her large plant, the firm reneges on her commitment and instead announces a $(\frac{1}{2}, \frac{1}{2})$ split. In that case, all n regions are participants in the bidding war for both plants. Since the establishments are of equal sizes, the winning bid for both will thus simply be equal to the third-highest valuation: $s_2^* = (\frac{1}{2})b_{(3)}$. Indeed, these bids are simply a special case of the bids derived in the benchmark model, with $\alpha = \frac{1}{2}$. Since the establishments have the same value, there is no competition among the last two regions remaining in the bidding war, and they both pay the same subsidy. This case is summarized in the first row of Table 2.1.

If $m = 1$, there is the only region suitable for the large investment. In this case, the region can bid as low as zero, and still win the investment with certainty. The winning bid for the largest establishment will thus be equal to zero: $s_1^* = 0$. The winning bid for the smaller establishment is determined by the competition among the remaining regions, and will be equal to the second-highest valuation among those regions, which is the third-highest valuation among all regions: $s_2^* = (1-\alpha)b_{(3)}$.[12]

If $m > 1$, the regions' behaviour looks similar to the benchmark model in which there was no infrastructure cost. In particular, the bid for the smaller establishment will be equal to the third-highest valuation: $s_2^* = (1-\alpha)b_{(3)}$. The bid for the larger establishment will be determined by the infra-marginal competition occurring between the two regions that have paid the infrastructure cost and have the highest two signals. As shown in Section 2.3, the equilibrium bid is $s_1^* = (2\alpha-1)b_{(2)} + (1-\alpha)b_{(3)}$.

[12] As we will see in the next section, all regions with a signal higher than the threshold pay the infrastructure cost, and no region with signals lower than the threshold do. Therefore, the only region incurring the infrastructure cost necessarily has the highest signal.

2.4.2 The Regions' Entry Decision

After observing the investment split chosen by the firm in Stage 1 (α), regional governments decide whether they want to participate in the bidding war for the larger establishment. We define b_t as the minimum signal (threshold) for which a region decides to make the necessary investment in infrastructure and compete for both the large and small establishments. Our goal is then to characterize this threshold value.

Take an arbitrary region i. For this region, there are three interesting outcomes: either it has the highest signal, the second-highest signal, or its signal is lower than at least two other regions. Now consider a region that is just at the threshold. In other words, this region is indifferent between incurring the infrastructure cost or not. Its payoff varies according to her position in the list and whether it paid entry or not. The following table summarises the different cases and associated payoffs.

Table 2.2: Decomposition of Possible Cases for the Threshold Region

Position	Pays infrastructure cost	Payoff to region
First	Yes	$\alpha b_t - c(\alpha)$
	No	$(\frac{1}{2})b_t - (\frac{1}{2})b_{(3)}$
Second	Yes	$(1-\alpha)b_t - (1-\alpha)b_{(3)} - c(\alpha)$
	No	$(1-\alpha)b_t - (1-\alpha)b_{(3)}$
Third	Yes	$-c(\alpha)$
	No	0

If the threshold region has the highest signal, it will always win the large establishment if it makes the required investment in infrastructure. The reason is that all other regions have a lower signal, and thus a signal lower than the threshold; they do not enter the auction for the large plant. Therefore, in this case, if the threshold region pays the infrastructure cost, it will receive a payoff of $\alpha b_t - c(\alpha)$. As noted earlier, it does not have to pay a subsidy. Indeed, since there is no competition, that region can submit a subsidy of zero and still win the auction. In effect, this corresponds to an absence of tax breaks. If the threshold region decides not to pay the infrastructure cost, the firm splits in two equal establishments, thus the threshold region receives one establishment and pays a subsidy equal to the third-highest valuation, corresponding to a payoff of $(\frac{1}{2})b_t - (\frac{1}{2})b_{(3)}$.

If the threshold region has the second-highest signal, it will always win the smaller establishment. If it pays the infrastructure costs, the region with a higher signal will win the auction for the large establishment, and the threshold region will win the small one, paying a bid equal to the third-highest valuation, corresponding to a payoff of $(1-\alpha)b_t - (1-\alpha)b_{(3)} - c(\alpha)$. If the threshold region does not pay the infrastructure cost, it will still win the small plant, pay the same subsidy, but its payoff will be higher since it did not invest in infrastructure. Its payoff is thus equal to $(1-\alpha)b_t - (1-\alpha)b_{(3)}$. Note that in this case, the large plant is awarded without competition and without subsidies.

Finally, if the signal of threshold region is the third-highest (or lower if more than three regions), it will never win any of the establishments. Therefore, if it pays the infrastructure cost, it receives a payoff of $-c(\alpha)$, while it receives a payoff of 0 if it does not incur the infrastructure cost.

Recall that we defined the threshold signal as the signal at which a region is indifferent between paying the infrastructure cost, and not paying it. To determine the value for the threshold, we can therefore calculate the expected payoff from both decisions using the values described above. In particular, the expected payoff when paying the infrastructure cost is determined by the probability of being first, second, or lower, and the payoff in each case. The expected payoff when not incurring infrastructure costs is determined in a similar way. We start by calculating the expected payoff when investing in infrastructure, which is equal to:

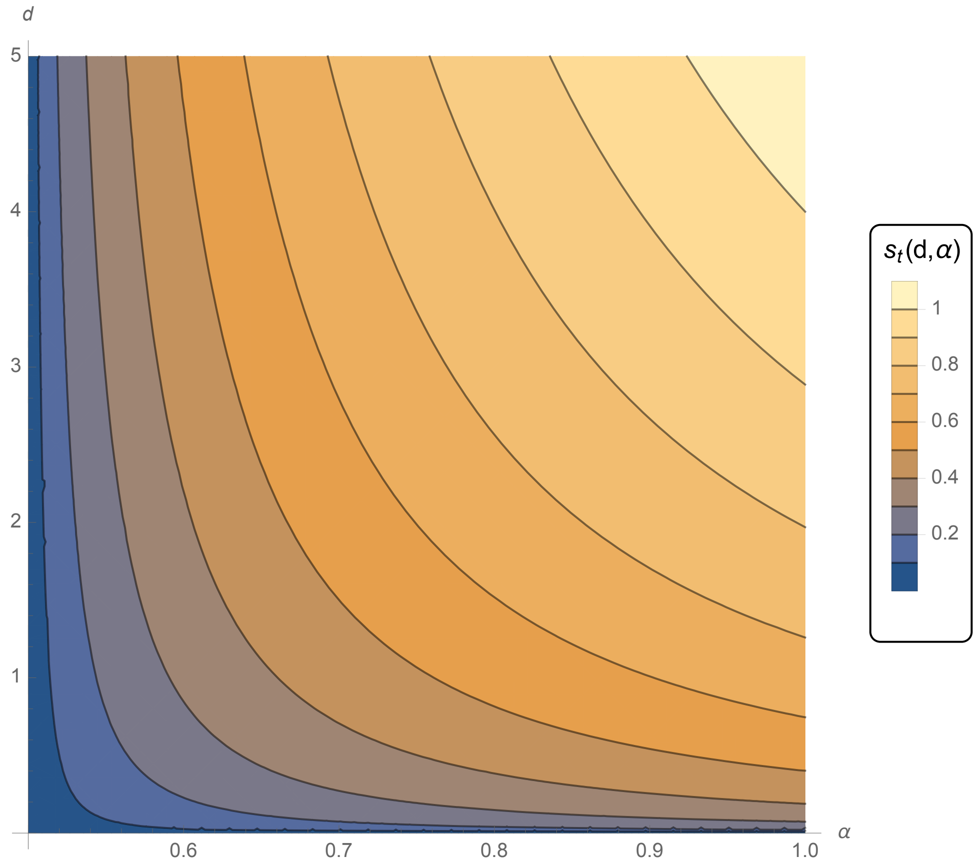
$$W^c = \int_0^{b_t}\int_0^{y}(\alpha b_t - c(\alpha))f_{x,y}(x,y)dxdy + \int_{b_t}^{1}\int_0^{b_t}((1-\alpha)b_t - (1-\alpha)x - c(\alpha))f_{x,y}(x,y)dxdy + \int_{b_t}^{1}\int_{b_t}^{1}(-c(\alpha))f_{x,y}(x,y)dxdy \quad (2.4.2)$$

Similarly, we calculate the threshold region's expected payoff when not paying the infrastructure cost:

$$W^0 = \int_0^{b_t}\int_0^{y}((\frac{1}{2})b_t - (\frac{1}{2})x)f_{x,y}(x,y)dxdy + \int_{b_t}^{1}\int_0^{b_t}((1-\alpha)b_t - (1-\alpha)x)f_{x,y}(x,y)dxdy + \int_{b_t}^{1}\int_{b_t}^{1}(0)f_{x,y}(x,y)dxdy \quad (2.4.3)$$

Setting $W^c = W^0$, we can find $b_t(d,\alpha)$: the signal at which a region is just indifferent between paying the infrastructure cost and not paying it. Regions with a lower signal will not pay the cost, thus only competing on the small plant, while regions with a higher signal will pay the infrastructure cost and compete on both establishments.

A complete analytical solution to $b_t(d, \alpha)$ is possible, although not informative. We instead describe the behaviour of that function with respect to both arguments. Figure 2.3 shows the value of the threshold signal for different values of d and α. The value of the threshold signal increases with α, and is unsurprisingly higher for higher d. The figure also clearly shows that for high values of d, the firm would actually drive all regions out of the competition if she decided to concentrate her production in a large establishment (remember that for simplicity, we assumed that signals are distributed in the $[0, 1]$ interval).



Note: Each line represents the values of d and α that give the same value of $b_t(d, \alpha)$.

Figure 2.3: Threshold Signal Value for Combinations of d and α

Lemma 2.2. *There exists some values of d for which the firm can drive out all competition for her investment if she chooses a high α.*

Proof. Private benefits b_i are distributed on the interval $[0, 1]$. If $b_t(d, \alpha) > 1$, then the threshold for entry is too high for any region to pay the infrastructure cost. Figure 2.3 illustrates such a case. For example, for $d = 5$, $\alpha > 0.93 \implies b_t(d, \alpha) > 1$. Therefore, for these values, the firm drives out all competition for her large establishment. ■

2.4.3 The Firm's Revenue Maximisation Problem

The firm wants to maximise the sum of the bids received for the establishments and her profits from production.[13] Before the auction takes places, the firm has to decide on a production split (α). The chosen split has consequences on the magnitude of the infrastructure cost, the profits of the firm, as well as on the valuation of the regions. She chooses α by maximising the expected value of her revenues.

For the firm, there are a few cases possible, depending on the number of regions who enter the competition. Indeed, as seen above, the number of regions competing for the large establishment will determine the winning bids received by the firm. Moreover, if no region competes for that establishment, she will not receive profits from it. Expressed in terms of these four case, the expected revenues of the firm are equal to:

$$\begin{aligned} E(R) = & \int_0^{b_t}\int_0^{x}\int_0^{y}[z+(h(\frac{1}{2})+h(\frac{1}{2}))\pi]g_{x,y,z}(x,y,z)\ dzdydx \\ & + \int_{b_t}^{1}\int_0^{b_t}\int_0^{y}[(h(\alpha)+h(1-\alpha))\pi+(1-\alpha)z]g_{x,y,z}(x,y,z)\ dzdydx \\ & + \int_{b_t}^{1}\int_{b_t}^{x}\int_0^{s_t}[(h(\alpha)+h(1-\alpha))\pi+2(1-\alpha)z+(2\alpha-1)y]g_{x,y,z}(x,y,z)\ dzdydx \\ & + \int_{b_t}^{1}\int_{b_t}^{x}\int_{b_t}^{y}[(h(\alpha)+h(1-\alpha))\pi+2(1-\alpha)z+(2\alpha-1)y]g_{x,y,z}(x,y,z)\ dzdydx \end{aligned} \tag{2.4.4}$$

Revenues come from three sources: profits from the small establishment, profits from the large establishment, and winning bids. We can already see that the firm always receives the profits from the small establishment, and the profits from the larger one in three out of four cases. It may be informative to calculate the total revenues from each source separately. Let's consider the expected revenues accruing from the profits of the small establishment:

$$E(R_s) = \int_{b_t}^{1}\int_0^{x}\int_0^{y} h(1-\alpha)\pi\cdot g_{x,y,z}(x,y,z)\ dzdydx \tag{2.4.5}$$

$$+ \int_0^{b_t}\int_0^{x}\int_0^{y} h(1/2)\pi\cdot g_{x,y,z}(x,y,z)\ dzdydx$$

$$= \pi\left((1-b_t^3)\cdot h(1-\alpha)+b_t^3\cdot h(1/2)\right) \tag{2.4.6}$$

[13] Note that in this section, the α that maximises the firm's revenues may not be the actual α realized. Indeed, we assumed that the firm may renege on her commitment. This behaviour, however, is anticipated by the regions in their entry choice. Moreover, their bids will be on the realized α.

First, we should note that the revenues from this plant can either increase or decrease with α, depending on the value of $\pi'(\alpha)$. If $\pi'(\cdot) = h'(\cdot) > 0$, the first derivative of $E(R_s)$ with respect to α is negative (or equal to zero if, for example, $\pi = 0$). Therefore, a lower production share in this plant translates in lower revenues. However, increasing α also increases the probability of no regions paying the infrastructure cost, and the firm reverting to $\alpha = \frac{1}{2}$, reneging on her commitment. We can see from the equation above that the expected revenues from the small establishment can take two distinct values, depending on the value of α, and that the probability of realisation of each value depends on the threshold signal (b_t^3 and $1 - b_t^3$).

Next, let's consider the expected revenues accruing from the profits in the large establishment.

$$
\begin{aligned}
E(R_l) &= \int_{b_t}^{1} \int_{0}^{x} \int_{0}^{y} h(\alpha)\pi \cdot g_{x,y,z}(x,y,z)\ dzdydx && (2.4.7)\\
&+ \int_{0}^{b_t} \int_{0}^{x} \int_{0}^{y} h(1/2)\pi \cdot g_{x,y,z}(x,y,z)\ dzdydx \\
&= \pi \left((1 - b_t^3) \cdot h(\alpha) + b_t^3 \cdot h(1/2) \right) && (2.4.8)
\end{aligned}
$$

If $\pi'(\cdot) = h'(\cdot) > 0$ ($\pi'(\cdot) = h'(\cdot) < 0$), increasing α translates in higher (lower) revenues from the large plant. However, a higher α also increases the threshold signal, and thus the probability that the firm will revert to a symmetric production split. Therefore, the choice of the firm has an ambiguous effect on her revenues accruing from the large establishment. As one would expect, high infrastructure costs either through a large d or higher α decreases the expected revenues from this establishment, by increasing the threshold signal. However, a large α also has the opposite effect on expected revenues by increasing profits.

To illustrate, Figure 2.4 plots the previous equation for $\pi = 1$, and for $h(\alpha) = \alpha^\lambda$, with various values of λ and d. The figure clearly shows the trade-off facing the firm. When costs are high, she tends to receive higher revenues from splitting her production, but a higher λ has the opposing effect.

The last portion of expected revenues accrues from the bids made by the region to the firm.

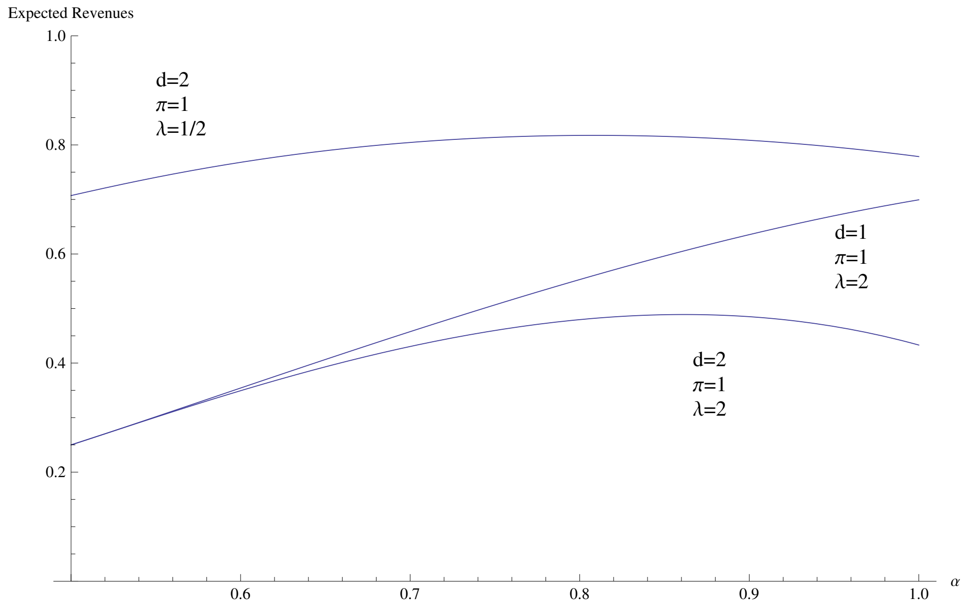


Figure 2.4: Expected Revenues from Large Establishment vs. α

It is separated in four distinct cases:

$$
\begin{aligned}
E(R_b) = & \int_0^{b_t}\int_0^{x}\int_0^{y}[z]\cdot g_{x,y,z}(x,y,z)\ dzdydx \\
& + \int_{b_t}^{1}\int_0^{b_t}\int_0^{y}[(1-\alpha)z]\cdot g_{x,y,z}(x,y,z)\ dzdydx \\
& + \int_{b_t}^{1}\int_{s_t}^{x}\int_0^{b_t}[2(1-\alpha)z+(2\alpha-1)y]\cdot g_{x,y,z}(x,y,z)\ dzdydx \\
& + \int_{b_t}^{1}\int_{b_t}^{x}\int_{b_t}^{y}[2(1-\alpha)z+(2\alpha-1)y]\cdot g_{x,y,z}(x,y,z)\ dzdydx \qquad (2.4.9) \\
& = b_t^3 - \frac{3b_t^4}{4} + \frac{1}{2}\alpha(1+b_t^3(-6+5b_t)) \qquad (2.4.10)
\end{aligned}
$$

This portion of expected revenues vary with α and the magnitude of the infrastructure costs (d), since these parameters affect the threshold signal and thus the number of entrants. When the firm introduces high infrastructure costs, the threshold increases and fewer regions pay the cost. In turn, the bids are lower, or even null for the large establishment. However, the firm can also increase the value of the bids by differentiating the two establishments. Indeed, this differentiation introduces infra-marginal competition for the largest establishment. Figure 2.5 illustrates the trade-off at play. We observe an inverse U-shaped relationship between α and the expected revenues from the bids. Moreover, as d increases, the magnitude of the costs increases, and the expected bids decrease as well. The firm's optimal split thus also decreases towards $\alpha^* = \frac{1}{2}$.

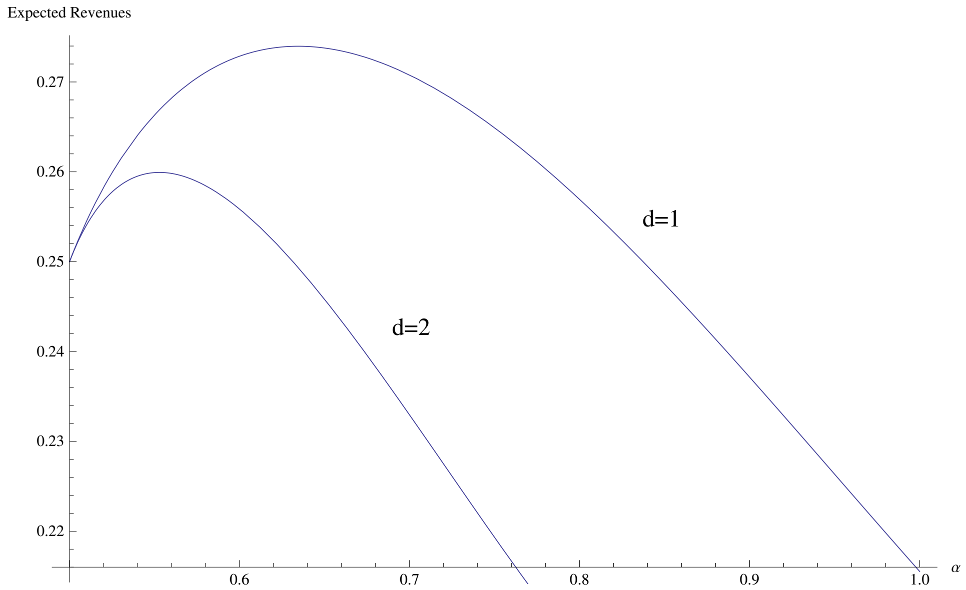


Figure 2.5: Expected Revenues from Bids, Depending on α

Combining the three portions we have discussed above, we can describe the total expected revenues of the firm.

Proposition 2.2. *There exist some parameters d (magnitude of infrastructure costs) and π (magnitude of potential profits) such that even $\lambda > 1$, the firm decides to locate her production in two asymmetrical establishments.*

Proof. We do not provide the full analytical solution for α^*, since it is not informative. Figure 2.6 illustrates a case in which the firm, although benefiting from increasing marginal returns to concentration ($\lambda = 2$), is better off splitting her production in two establishments (with $d = 2$ and $\pi = 2$). The example also assumes a uniform distribution of private benefits on $[0, 1]$

■

In general, higher infrastructure costs (higher d) tend to favour a production split closer to $\alpha^* = \frac{1}{2}$. Like in the simple example of the previous section, increasing marginal returns to concentration (larger λ) tend to favour concentration. In fact, in the simple example, we found that the firm always concentrated her production as $\lambda \geq 1$. In the presence of infrastructure costs, however, it is possible that the firm chooses to split her production even if she would benefit from increasing marginal returns to concentration.

In the case of the simple model without infrastructure costs, Figure 2.1 showed a stylised version of the optimal split for a range of values for λ. Figure 2.7 repeats the exercise for the full model we just described. We take a value of $d = 1$, and look at the optimal split for various

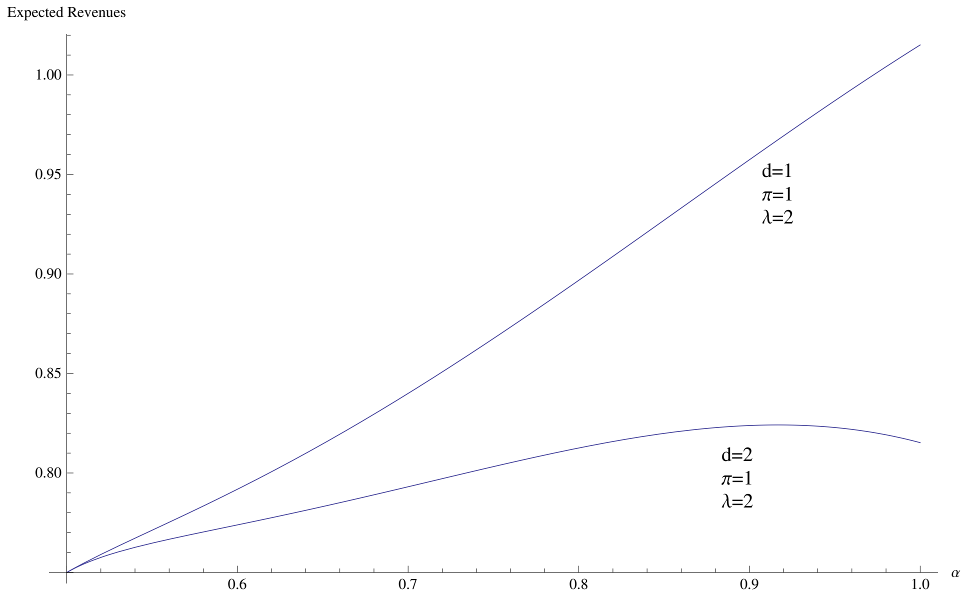


Figure 2.6: Total Expected Revenues, Depending on α

values of λ. Most strikingly, we find that with this magnitude of infrastructure costs, the firm can benefit from increasing marginal returns to concentration but still decide to split in multiple establishments.

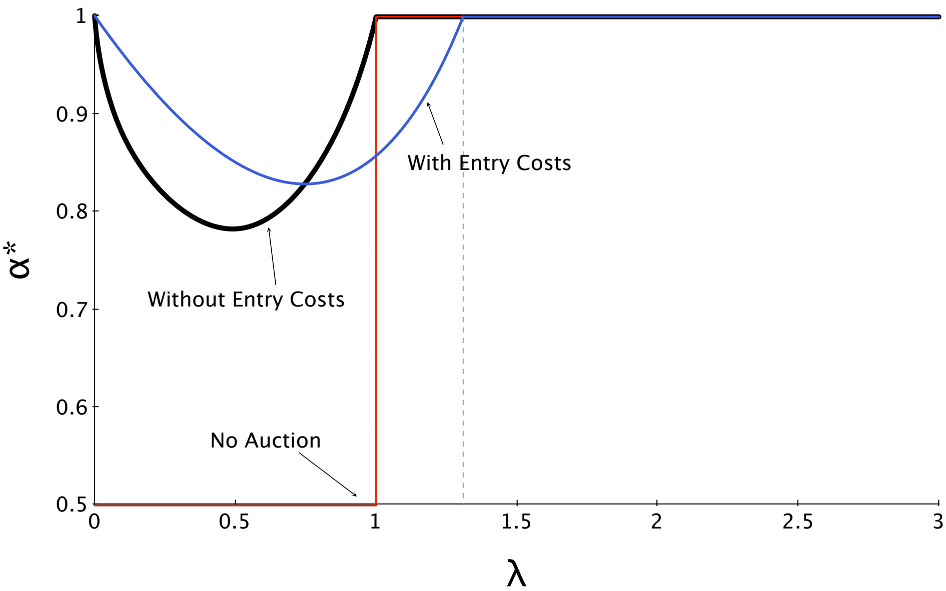


Figure 2.7: Optimal α for various values of λ, with infrastructure costs

2.5 Welfare

We have shown that a bidding war may affect the firm's allocation of investment across production sites. One remaining question is how these bidding wars may affect social welfare. Let's first suppose that a social planner has complete information about the regions' signals, and maximises a social welfare function defined as

$$W_{inf} = \pi(\alpha_{inf}) + \pi(1 - \alpha_{inf}) + \alpha_{inf} b_{(1)} + (1 - \alpha_{inf}) b_{(2)} \tag{2.5.1}$$

We assume, first, that $c(\alpha) = 0$ (no necessary investment in infrastructure). The first-order condition is equal to

$$\begin{aligned} \pi'(\alpha_{inf}) - \pi'(1 - \alpha_{inf}) + b_{(1)} - b_{(2)} &= 0 \\ \pi'(1 - \alpha_{inf}) - \pi'(\alpha_{inf}) &= b_{(1)} - b_{(2)} \end{aligned} \tag{2.5.2}$$

Since $b_{(1)} - b_{(2)} > 0$, the FOC implies that $\pi'(\alpha_{inf}) < \pi'(1 - \alpha_{inf})$. Therefore, with $\pi''(\cdot) < 0$, the optimal solution is always at $a_{inf} > \frac{1}{2}$. In other words, the social planner always chooses differentiated establishments, just like the firm would herself do by using a bidding war. This distortion in the firm's investment allocation resulting from the auction (when $\pi''(\cdot) < 0$), however, is different from the distortion that existed in the auction.

Proposition 2.3. *Assume private benefits are distributed according to a uniform distribution. Then, a perfectly-informed social planner differentiates the firm's establishments, but less than the firm would using a bidding war.*

Proof. In a bidding war, the firm chooses an optimal split according to the inequality $\pi'(1-\alpha) - \pi'(\alpha) = 2E(b_{(2)} - b_{(3)})$. In general, $b_{(1)} - b_{(2)}$ is obviously not equal to $2E(b_{(2)} - b_{(3)})$. In fact, in expected values and with a uniform distribution (so $E(b_{(k)} - b_{(k+1)}) = E(b_{(n)})$), $2E(b_{(2)} - b_{(3)})$ is twice as large as $b_{(1)} - b_{(2)}$. In other words, the bidding war introduces a larger distortion than a perfectly-informed social planner would. ■

If $\pi''(\cdot) > 0$, then the social planner's solution is to concentrate all production into one large establishment. The firm chooses the same α in a bidding war under this condition.

This result shows that a bidding war and an informed social planner leads to a similar allocation of production. In both cases, the establishments are differentiated. However, the firm and the social planner get to that allocation through very different mechanisms. In the bidding war, the firm chooses a level of differentiation to maximise the expected bids, through infra-marginal competition. Therefore, she takes into account the distribution of the second- and third-highest signals. The social planner, on the other hand, chooses to differentiate the establishments because the regions have different levels of private benefits. The planner therefore chooses to increase investment in the large establishment, to the benefit of the region with largest private benefits.

To illustrate the difference, let's assume a uniform distribution on $[0, 1]$. In this case, with 3 regions, $2E(b_{(2)} - b_{(3)}) = \frac{1}{2}$. For the social planner to choose the same level of differentiation as the firm, there would need to be a difference of $\frac{1}{2}$ between the realizations of the first two signals, or twice the expected difference of $\frac{1}{4}$. Obviously, though, any combination of realised signals is possible.

If the social planner did not know the exact signals, but only their distribution like the firm does, we would have the following first-order condition:

$$\pi'(\alpha_{un}) - \pi'(1 - \alpha_{un}) + E(b_i) - E(b_j) = 0 \tag{2.5.3}$$

with i, j the two regions hosting the investment. The social planner, in this case, can do no better than to choose two regions randomly. Since $E(b_i) = E(b_j)$, the social planner chooses α such that the marginal profits in the two establishments are equal. In other words, he chooses the no-bidding war solution that we described earlier: $\alpha = \frac{1}{2}$ with decreasing marginal returns to concentration, and $\alpha = 1$ with increasing marginal returns to concentration.

To see how the bidding war may affect social welfare, let's define social welfare under a bidding war as such:

$$W_{bw} = \pi(\alpha_{bw}) + \pi(1 - \alpha_{bw}) + \alpha_{bw} b_{(1)} + (1 - \alpha_{bw}) b_{(2)} - \gamma \cdot (s_1 + s_2) \tag{2.5.4}$$

where γ is the marginal cost of raising public funds, the dead-weight loss incurred by the regional governments in raising revenues to pay the subsidies. Note that the subsidies themselves are simply transfers. Here, α_{bw} is chosen by the firm, as in the previous sections.

Lemma 2.3. *For low enough marginal costs of public funds, expected social welfare is higher under a bidding war than under an uninformed social planner.*

Proof. If we can prove that $\forall \alpha$, $W_{bw} > W_{un}$, then we know that at the respective optimal values of α, $W_{bw}(\alpha_{bw}) > W_{un}(\alpha_{un})$.

Take an arbitrary α. Then, $E\left[W_{bw}(\alpha)\right] > E\left[W_{un}(\alpha)\right]$ if and only if:

$$\begin{aligned} E\left[\pi(\alpha)+\pi(1-\alpha)+\alpha b_{(1)}+(1-\alpha)b_{(2)}-\gamma\cdot(s_1(\alpha)+s_2(\alpha))\right] &> E\left[\pi(\alpha)+\pi(1-\alpha)\right]+E(b) \\ E\left[\alpha b_{(1)}+(1-\alpha)b_{(2)}-\gamma\cdot((2\alpha-1)b_{(2)}+2(1-\alpha)b_{(3)})\right] &> E(b) \\ m &< \frac{1}{2} \end{aligned}$$

In the third step, we assumed, as before, that the private benefits are distributed according to a uniform distribution on $[0,1]$. Therefore, for $\gamma < \frac{1}{2}$, social welfare is higher, in expected terms, under a bidding war than under an uninformed social planner. ■

This result is intuitive. Suppose we must decide, as an uninformed social planner, whether to maximise social welfare using our limited information, or let the firm conduct a bidding war. If raising revenues is not too costly for the government (in terms of administrative costs or distortions), then it is worthwhile to do so and achieve a better allocation of establishments to regions. However, that result might not hold if the social planner observes the private benefits of every region.

Lemma 2.4. *Expected social welfare is always lower under a bidding war than under a perfectly-informed social planner.*

Proof. As previously, we only need to prove that $\forall\alpha$, $W_{bw} < W_{inf}$. Take an arbitrary α. Then, $E\left[W_{bw}(\alpha)\right] < E\left[W_{inf}(\alpha)\right]$ if and only if:

$$\begin{aligned} E\left[\pi(\alpha)+\pi(1-\alpha)+\alpha b_{(1)}+(1-\alpha)b_{(2)}-m\cdot(s_1(\alpha)+s_2(\alpha))\right] &< E\left[\pi(\alpha)+\pi(1-\alpha)+\alpha b_{(1)}+(1-\alpha)b_{(2)}\right] \\ E\left[\alpha b_{(1)}+(1-\alpha)b_{(2)}-m\cdot((2\alpha-1)b_{(2)}+2(1-\alpha)b_{(3)})\right] &< E(\alpha b_{(1)}+(1-\alpha)b_{(2)}) \\ E[-m\cdot((2\alpha-1)b_{(2)}+2(1-\alpha)b_{(3)})] &< 0 \end{aligned}$$

Since $m > 0$ and $s_1(\alpha)+s_2(\alpha) \geq 0$, the previous is always true. Therefore, $\forall\alpha$, $W_{bw} < W^{inf}$. ■

This result is not very surprising. A social planner with all the information can achieve the allocation of establishments to the regions that value it the most, without the added cost of raising public funds to pay subsidies to the firm. The previous two lemmas thus show that social welfare under a bidding war falls under the two extreme assumptions of information for the social planner.

Proposition 2.4. *Social welfare under a bidding war is lower than social welfare under a perfectly-informed social planner, but higher than under an uninformed social planner.*

Proof. See Lemmas 2.3 and 2.4. ■

As an example, assume that $\pi(\alpha)$ takes the same functional form: $\pi(\alpha) = \alpha^{\frac{1}{2}}$. Also assume a uniform distribution on $[0, 1]$ Figure 2.8 shows social welfare under the three possibilities.

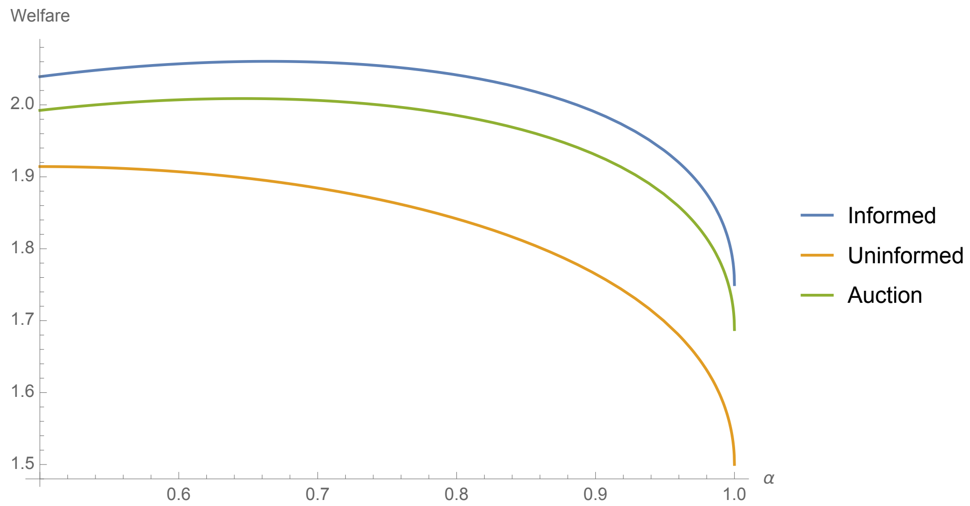


Figure 2.8: Social Welfare Under Three Possibilities

Finally, the addition of prior investment in infrastructure modifies the welfare implications of the model. Since the infrastructure costs are needed only to host the firm, the social planner would only impose these costs once, in the winning region. In the bidding war, the number of regions why pay the infrastructure varies. When more than one region pays the infrastructure cost, social welfare is lower. This result follows from how we modelled infrastructure investment, which has no benefit other than allowing a region to host the firm (such as signalling or productivity differences). *Ex ante*, the number of regions who pay the infrastructure cost depends on the shape of the distribution function of private benefits.

2.6 Conclusion

This chapter studies how bidding wars for multiple investments can influence the allocation of investment of the firm across sites. It introduces an additional trade-off that was absent from the first chapter of this thesis, as well as from the previous literature. In particular, when investment quantities are endogenous, we have to consider whether their sizes affect the infrastructure required to host the plant, and whether regions wish to make infrastructure costs in order to participate in the bidding war. We explore this question by building a model where regions may have to make investment in infrastructure before participating in the bidding war, assimilating these infrastructure costs to entry costs in an auction.

In the first chapter, we showed how a bidding war can incite a firm to differentiate her establishments, in order to attract greater subsidies. In this chapter, we argue that by increasing the size of one of the establishments, this establishment requires a greater level of infrastructure to host. Consequently, regions have to pay a greater cost to participate in the bidding war, thereby potentially reducing the number of regional governments competing for the larger plant. In turn, when the firm increases the differentiation between her plants, she runs the risk of driving all regions out of the bidding war, and receive lower subsidies. In the extreme case, a firm with a production technology such that she chooses to produce in a single large plant in the benchmark case without the prior investment in infrastructure would choose to invest in two plants when the bidding war includes a prior stage of infrastructure investment.

The infrastructure costs in this chapter were modelled such that they allow regions who make them to participate in the bidding war. Consequently, from the point of view of a social planner, it is socially optimal to make this investment in infrastructure in only one region. This conclusion differs from, e.g., Jayet and Paty (2006), who find it socially optimal to have investment in infrastructure in many regions. Like this chapter, however, Jayet and Paty (2006) find that in a competition between many local governments, too many localities may pay the infrastructure cost. The difference between these models is in part due to the modelling choice of information asymmetry. Jayet and Paty (2006) assume the opposite, such that it is optimal to develop more than one site to increase the probability of developing at least one high-productivity site. In this chapter, the regions have more information than the firm, and there are no productivity differences.

The model in this chapter uses an open ascending auction. It could prove interesting to determine whether this auction can implement the optimal mechanism, as was the case in Chapter 1. We leave this for future research. Menezes and Monteiro (2000) show, however, that in auctions with endogenous participation, the optimal auction features a reserve price higher than under an auction with a fixed number of participants. In the terms of our model in Chapter 1, then, taking endogenous entry of regions into account may have a negative impact on social welfare; the firm would more often choose not to allocate the plants.

Chapter 3

Diversity and Municipal Secession: Evidence from Referendums in Quebec[1]

[1]In the preparation of this chapter, I benefitted from helpful discussions and suggestions with Mohammad Arzaghi, Philippe Bontems, Charlotte Cavaillé, Philippe De Donder, Dong-Hee Joe, Dominik Duell, Horracio Larreguy, Michel Le Breton, Thierry Madiès, Mickaël Melki, Pierre-Henri Morand, Sonia Paty, Tuukka Saarimaa, Melissa Sands, Janne Tukiainen, and Karine Van der Straeten. This chapter also benefited from interactions in presentations at the following seminars and conferences: Workshop on Cultural Diversity at Paris School of Economics, Public Economics seminar at Toulouse School of Economics, the 2015 Meetings of the Canadian Economics Association, the 2015 Spring Meeting of Young Economists, the Political Economy Seminar at the IQSS of Harvard University, the 2014 French Economics Association conference, a seminar at the VATT (Helsinki), the 2013 European Public Choice Society conference, and a seminar at the University of Le Havre (France).

3.1 Introduction

In recent years, several countries experienced municipal consolidation, including Canada in the 2000s, but also Japan and several European countries such as Finland and France. While central governments promise cost savings following mergers, voters may have different priorities and oppose them, as evidenced in the Canadian case. In fact, the economic literature on endogenous borders often emphasises a trade-off between economies of scale and heterogeneity of preferences (see, e.g., Alesina and Spolaore, 1997). Larger jurisdictions can more efficiently provide public goods, but there might be a better match between the preferences of voters and the public good in smaller jurisdictions.

However, in their study on the borders of local jurisdictions, Alesina, Baqir, and Hoxby (2004) point out that voters may dislike heterogeneity for two reasons. The first reason is the one just mentioned: heterogeneity results in greater differences between a voter's preferences for public goods and those of other voters in the same town. The second reason is that voters inherently dislike living in a jurisdiction with people different from them. In fact, Putnam (2007) argues that people in diverse neighbourhoods "hunker down;" they have lower trust in others and fewer friends. Other researchers have shown that the co-existence of different ethnic groups in municipalities or communities can lead to public goods of lower quality (Alesina et al., 1999; Algan et al., 2016), or to lower spending on social welfare (Luttmer, 2001). In other words, voters may exhibit some loyalty towards their own ethnic group. Alesina, Baqir, and Hoxby (2004) conclude that both channels must be effective, but their results do not distinguish between the two. The main goal of this chapter is to determine whether only one or both channels are present in the decisions of voters.

To do so, I use data from a set of municipal referendums in the Canadian province of Quebec. After the provincial government unilaterally enforced a wave of municipal mergers in 2001, public opposition led to a change of government in the following elections. Having campaigned on the idea of reversing these mergers, the new government organized, in 2004, simultaneous public consultations in the 213 cities that were part of the merger wave. In this consultation process, voters were asked whether they wanted their pre-merger town to secede from the consolidated municipality or not. In the analysis, I use the consultation results as the dependent variable, and look at the effect of a number of socio-economic factors on whether a town decides to secede or not. Moreover, the co-existence of two language groups in Quebec allows me to study how ethn-linguistic diversity affected the choice of voters. Indeed, in Quebec, language is at the foundation of a strong "ethnic" identity.[2] The mergers created by the central government amalgamated towns with significantly different linguistic compositions. I can use this characteristic to investigate whether greater differences in language composition resulted in more secessions.

This chapter contributes to three literatures: the literature on municipal consolidations and secessions, the literature on the provision of local public goods in diverse communities, and the more general literature on secessions.

To the literature on municipal mergers, the originality of this chapter is twofold. First, my results suggest that voters prefer homogeneous cities not only because such a city results in a better match between their preferences and the public goods, but also because they dislike sharing a jurisdiction with people of different ethnic backgrounds. I obtain this finding by looking at interaction effects, based on the following argument. Indeed, while I find that both larger language and income differences between a town and its merging partners (the other towns part of the same consolidation or merger) are associated with an increased probability that this town will secede from the merger, I also find that these two variables are not independent. In particular, the effect of income differences on the probability of a town secession is stronger when language differences are larger. The argument is as follows. If voters dislike living with different people, they would be less likely to accept compromises on the provision of the public goods when mixed people of other ethnicities (a reasoning similar to that of Luttmer (2001) for social welfare spending in the US). Therefore, while voters may be more likely to vote for a secession when faced with greater differences in income, that effect should be larger when language differences (an important marker of ethnicity in Quebec) are larger. In other words, individuals more readily accept having people of different incomes (and preferences) in the same jurisdiction, and thus compromise on the composition of the public good, when these people share a common group identity (in this case, language). This result is robust to the addition of additional variables such as differences in house values and turnout at the referendum, and to the choice of specification, including to the inclusion of a spatial lag.

[2]For historical context on language and identity in Quebec, see Taylor, Bassili and Abboud (1973) and Thompson (1995). A more general treatment on the role of language in the formation of identity is provided in Edwards (2009). In Spain, for example, language is a strong differentiator between Catalonia and the rest of the country. In that region, Clots-Figueras and Masella (2012) find that individuals who had greater exposure to the Catalan language in school had a greater probability to support regional parties. These results support the idea that language is important in the formation of group identity. In Quebec, the French-speaking majority actually organised two secession referendums in 1980 and 1995, from Canada as a whole.

The second originality of this chapter compared to most of the literature on municipal borders is due to the source of the data. Indeed, by using referendums, I can study the preferences of voters directly, instead of relying on the choices of local government officials, who may be swayed by many different political factors. Hyytinen, Saarimaa, and Tukiainen (2014), for example, show that politicians may vote for or against mergers based on career considerations, instead of voter preferences. Brink (2004) uses data from public consultations in Swedish municipalities. However, her dataset only includes few observations over 20 years, and the referendums took place only in cities that officially requested one. In my chapter, the central government itself organised 213 referendum processes, and those referendums all took place simultaneously.[3] Tanguay and Wihry (2008) used data from the same events, but they do not explain why linguistic diversity affects border choice. My analysis differs from theirs on three fronts. First, I provide evidence suggesting that group loyalty is an important factor, thus providing a better explanation of *why* language differences matter in these referendums. Second, I use a method that considers the probability of actual secessions instead of the number of votes, which also allows the use of the full sample of 213 cities instead of a reduced sample of 89 cities. Third, I include additional variables such as house values (reflecting wealth) and political preferences, thus refining the analysis of these referendum votes.

The use of referendums on *de-mergers* also presents advantage in contrast to analyses of *mergers*. Indeed, I can circumvent much of the difficulties encountered by other researchers studying municipal mergers. Saarimaa and Tukiainen (2014) explain these difficulties in depth. In summary, the difficulty results from the impossibility to observe alternative mergers that were not chosen. Indeed, mergers are only observed when all partners agree to it, and while all towns can choose from multiple potential mergers, they can only choose one merger. With the inability to observe the non-chosen mergers, it can be difficult to explain the determinants of any city's choice. Researchers can overcome these difficulties in different ways, such as using structural methods (e.g., Weese, 2015), or by only looking at the end result of decades or mergers and secessions (e.g., Alesina, Baqir, and Hoxby, 2004). Di Porto, Merlin and Paty (2013) instead look at formal cooperation agreements between municipalities in France, a version of joint public goods provision that is less extreme than outright merger. Saarimaa and Tukiainen (2014), for their part, create a dataset of all potential mergers in Finland, and compare the observed

[3] The central government opened a register for signatures simultaneously in the 213 towns that were previously forcibly merged. Only 89 towns actually had a referendum, although the absence of a referendum can be observed and is indicative of a low support for secession.

mergers to potential mergers, thus changing the unit of observation from city to merger. With data from *de-merger* referendums instead, the analysis is much simpler. Voters are asked to express their opinions, choosing between only two alternatives: accept the merger, or secede from the consolidated town. This approach also eliminates the need to look at all possible mergers, since at the time of the referendum, these alternative mergers are irrelevant. Moreover, the agents making the choice in my data, the voters, had no say in the prior creation of the mergers.

I also contribute to the literature on the provision of local public goods in diverse communities (see reviews by Alesina and La Ferrara (2005) and Stichnoth and Van der Straeten (2013)). Papers in that literature show that the amount and composition of public goods delivered in local jurisdictions, or the support for welfare spending or redistribution, depend on the demographic make-up of the region. Cutler et al. (1993) argued that this relationship is not explainable by Tiebout sorting, but that voters have community-dependent preferences. Later research by, e.g., Luttmer (2001) and Lind (2007) reinforced the idea that voters care about the identity of other people receiving the public goods (or redistribution). In other words, group loyalty matters: individuals favour people in their group. In this chapter, I argue that this effect could also be present in the choice of local borders. In fact, secession gives voters the opportunity to create a more homogeneous jurisdiction in which to provide local public goods.

Finally, this chapter is also related to the study of secessions at a national level. The main argument of that literature is that with larger jurisdictions, economies of scale lead to more efficient provision of public goods, but smaller jurisdictions can provide a bundle closer to the citizens' preferences (Alesina and Spolaore, 1997; Bolton and Roland, 1997). That trade-off is also at play in the work of Oates (1972) on fiscal federalism. There are some differences between municipal and national secessions. For example, the rules in the referendums studied in this chapter were clear, thus reducing the uncertainty usually present in national referendums. Also, since local governments are relatively smaller spenders, the stakes could be lower in the minds of some voters. That being said, the arguments of the secession literature are still relevant for municipalities. In fact, while the formal model of Alesina and Spolaore (1997) considers the number of countries, it also applies to lower levels of government. Therefore, if I find that group identity plays a role in small jurisdictions, it could certainly play a role in regional secessions.[4]

[4] In the case of regions seeking autonomy from a state, the attachment to a national identity is often very clear. For example, in 2012, 69 per cent of persons living in Scotland declared they either felt "Scottish not British," or "more Scottish than British" (Park et al., 2013). That sense of belonging to the Scottish identity

The next section reviews a selection of the literature related to the work in this chapter, including other works on the factors leading to municipal mergers and de-mergers, both from the point of view of governments and voters. It also discusses in greater detail how diversity plays a role in the provision of public goods, and how it may also affect votes on local borders. Section 3 provides some context on the municipal organization in Quebec, and the policies that led to these referendums. Section 4 presents the general empirical strategy of this chapter, along with the variables included in the analysis. Section 5 presents the empirical results, while Section 6 provides some robustness checks. The last section concludes.

3.2 Municipal Consolidations: Economies of Scale, Heterogeneity of Preferences, and Diversity

To provide some context for my empirical analysis, this section reviews a selection of papers on municipal consolidations, highlighting the factors that lead to mergers (or the opposition to them). It then reviews some theoretical and empirical evidence about the effect of ethnic diversity on the provision of public goods, to explain how ethnic diversity may also affect municipal borders.

3.2.1 Empirical Analyses of Municipal Mergers and De-Mergers

The study of municipal consolidations is closely linked to the question of the optimal size of jurisdictions. Oates (1972) and Alesina and Spolaore (1997), in particular, discuss the trade-off involved in determining the size of jurisdictions. On the one hand, larger jurisdictions bring economies of scale in the provision of public goods. However, on the other hand, larger jurisdictions are also accompanied by a greater heterogeneity of preferences for public goods. This trade-off drives a large part of the literature on municipal mergers. For example, Alesina, Baqir and Hoxby (2004) find that "there is strong evidence that people are willing to sacrifice economies of scale in order to avoid racial heterogeneity in their local jurisdiction." They also find some evidence, albeit weaker, for a trade-off between economies of scale and income heterogeneity. They do so by analysing how the number of local jurisdictions (e.g., school districts) in US counties vary according to different measures of heterogeneity.

Their result considers the end result of many decades of mergers, annexations, and seces-

was certainly one factor pushing for the organization of the secession referendum in 2014.

sions.[5] In an earlier paper, Nelson (1990) uses a similar approach with the number of local governments in about 300 metropolitan areas in the US. He finds that income, race, and age heterogeneity increases the number of local jurisdictions. In contrast to these two papers, my dataset allows for a direct investigation of voter preferences in specific referendums.

Other papers instead study specific examples of municipal border modifications. They differ on two important dimensions. Some study events of municipal mergers, while others are interested in de-mergers. Also, some study the choices of elected officials, while others are interested in the preferences of voters. Table 3.1 shows a classification of a selection of papers according to these two dimensions.

Table 3.1: Selection of Papers on Municipal/Local Jurisdiction Consolidations

	Mergers	De-Mergers
Analysis of Elected Officials Choices (or implied)	Weese (2015)[a] Saarimaa and Tukiainien (2014) Hanes et al. (2009) Sorensen (2006) Brasington (1999, 2003) Austin (1999)	n.a.
Analysis of Voter Choices	Miyazaki (2014)[b]	Tanguay and Wihry (2008) Brink (2004) *Current chapter*

[a] Weese (2015) uses data from Japanese municipal mergers. Some of these mergers included direct voter consolidations, but those are not used specifically in his paper. Miyazakz (2014) studies these referendums directly.

[b] Miyazaki (2014) studies results of voter referendums in Japan, although they were technically non-binding.

In this chapter, I consider specific instances of de-mergers of municipalities. In that respect, my analysis is more closely linked to the works of Brink (2004) and Tanguay and Wihry (2008). Brink (2004) studies a set of municipal referendums that took place in Swedish municipalities between 1977 and 1999. She finds that wealthier neighbourhoods are more likely to vote for secession. Her results, however, are based on only few referendums that were specifically requested by citizens of the voting municipalities, spread over two decades. Moreover, the referendum results had to be approved and accepted by the central government (i.e., the results were non-binding).

The referendums in Quebec are thus unique. They took place simultaneously, were numer-

[5] In their paper, Alesina, Baqir, and Hoxby (2004) also use panel data that features exogenous variation in the level of diversity due to migration of Blacks from the South to the North during the World Wars. With these data, they are able to argue for a causal estimate of diversity on the number of jurisdictions. They find that counties that were affected by the Black Migration had, on average, more districts after the two world wars.

ous, and the results were binding. Tanguay and Wihry (2008) recognized the uniqueness of these referendums and analysed the results. They find that more individuals vote for secession in towns that: spent different amounts on public goods than their merging partners, have different median incomes, and have different linguistic compositions. However, they did not explain why ethnic differences may affect voters' decisions on municipal borders. In this chapter, I will address this issue, and provide some evidence that ethnic groups do not matter only because they have different preferences for the public goods, but also because of a "group loyalty" effect. More precisely, I show that individuals more readily accept having people of different incomes in the same jurisdiction when these people share a common group identity (in this case, language). Furthermore, my analysis will focus on the probability to secede, instead of the share of votes for secession, thus using the full sample of 213 referendums, in contrast to the 89 in Tanguay and Wihry (2008). I also show that this distinction can be important. Because of the minimum turnout rule, the definition of the dependent variable affects the results.

This work is also related to papers analysing specific examples of municipal *mergers*. One example is the work of Miyazaki (2014), who studies the municipal mergers that took place in Japan in the early 2000s. These mergers were decided locally, but many localities organised referendums to approve consolidation before implementing them. Miyazaki finds that consolidations were more successful when accompanied by an increase in the efficiency of public goods provision, indicating that voters take economies of scale into account. He also finds that grants from the central government play a role (although Weese (2015) shows that in the Japanese case, these transfers were too low to attain the optimal number of mergers). The referendums in Japan, however, were not mandatory and were non-binding.

Table 3.1 shows that many of the past analyses rely on the choices of elected officials. However, politicians may have considerations other than voter welfare when choosing borders. Hyytinen, Saarimaa, and Tukiainen (2014), for example, show how politicians may vote for or against mergers based on career considerations, which may conflict with voter preferences. Since I am interested in the preferences of *voters* regarding local borders, my analysis on voter referendums is more appropriate.

Hanes et al. (2009), like Brink (2004), use data from Swedish municipalities, but from the 1950s, and where decisions were taken by elected officials instead. After a national policy of (state-imposed) municipal mergers, individual municipalities were given the opportunity to comment on the final merger, expressing their approval of or opposition to the amalgamation.

They find a quadratic effect of population size: small and large municipalities are more likely to accept the merger. Small cities may have more to gain from a merger in terms of economies of scale, while large municipalities have the less to lose in terms of loss of control. Medium-sized cities, however, may have only limited potential gains from economies of scale and somewhat large costs in terms of loss of control. They find only limited evidence for an effect of income (richer cities more likely to accept), but no effect from income differences between a town and the merger.

In contrast to the papers by Miyazaki (2014) and Hanes et al. (2009), empirical analyses of municipal consolidations are often complicated due to the matching process between municipalities. Saarimaa and Tukiainien (2014) point out the difficulties encountered in their own work as well as that of others. In particular, studying mergers directly requires analysing a two-sided decision. Localities can usually merge with any of their neighbours, but we only observe the merger with the partner(s) they chose. Furthermore, these neighbours themselves choose their own partners, and a merger including a large number of cities can be blocked by one potential partner, thus changing the set of choices for the whole region.

Saarimaa and Tukiainien (2014) solve this problem by creating the set of all possible (realistic) mergers, and conducting the analysis at the merger level. They find officials were less likely to implement mergers when it would imply a greater geographic distance between the median voter of the merger (calculated using GIS data) and the likely administrative centre (the largest city). In this way, the mergers implemented were somewhat in line with voter preferences. Expenditure heterogeneity is another important predictor of mergers in their analysis, while income heterogeneity does not affect the probability of a merger. Another interesting finding is that voters do not seem to look for economies of scale in mergers, although this result may be due to existing cooperation among many towns prior to mergers.

Brasington (1999, 2003) looks at cooperation for the provision of public schooling, and uses a bivariate Probit to account for the correlation between neighbouring districts' decision to cooperate. Notably, Brasington (2003) finds that the race composition of communities affects who they will cooperate with. For example, he finds that whiter communities are more likely to cooperate with less white communities, as long as incomes are similar. More precisely, whiter communities are less likely to cooperate with both richer and poorer non-white communities. In contrast to Brasington, my analysis will consider the actual decisions of voters, and not those of officials. Also, it will examine decisions on outright mergers at the municipality level, instead of collaboration on specific topics such as schooling.

Sorensen (2006) relies instead on answers to a questionnaire administered to mayors and local officials in Norway. This survey measures the preferences of these official for mergers with their neighbours. He relies, like previous papers, on the trade-off between economies of scale and preference heterogeneity. He finds that support for mergers increases as efficiency gains are larger, but also that officials from richer towns are less likely to favour merger with poorer neighbours. He measures differences in preferences using differences in political party preferences, finding that towns with dissimilar party preferences are less likely to merge. However, he is also interested in political factors and the effect of grants from central governments. In particular, generous central government grants are an impediment to voluntary mergers. Also, officials of small towns are less likely to support mergers, possibly because they expect positions of lower prestige and importance in merged entities.

Other authors turn to structural methods to solve the many empirical difficulties. Weese (2015) uses data from a wave of consolidation of Japanese municipalities. He estimates a structural model, and finds that the number of mergers was sub-optimal, probably due to financial incentives from the central government that were to weak. One advantage of a structural method is the ability to conduct counter-factual simulations. In an earlier version of his paper, Weese ran such simulations, finding that providing financial incentives only to the municipalities that are most opposed to mergers (the richest) can increase welfare. Gordon and Knight (2009) also use a structural method to analyse the factors that led to school district consolidations in the state of Iowa in the 1990s. However, as pointed out by Saarimaa and Tukiainen (2014), structural approaches also have drawbacks. Indeed, it is impossible to use natural experiments for causal analysis, and the included set of covariates is necessarily limited.

In the US, many municipal consolidations happen through annexations of suburbs by central municipalities. Austin (1999) studies these annexations and finds that, contrary to popular belief, city politicians do not mainly use annexations to increase their fiscal base. Instead, political factors play a larger role. Indeed, he finds that annexations are motivated by a desire to offset the change in the cities' demographic composition arising from the migration of poorer people to the inner cities, and of richer people to the suburbs. Austin (1999) also notes that race did play a small role in annexations, although politicians did not simply annex white neighbourhoods *per se*. However, the annexations did result in an increase in the ratio of white people in the new city, thus diluting the political power of non-whites.

3.2.2 Diversity and Local Public Goods

Racial or ethnic composition is a common factor in many of the papers cited above. Notably, Alesina, Baqir, and Hoxby (2004) mention the idea that citizens may dislike interacting with others of different ethnic backgrounds. For example, voters may dislike redistribution or social welfare spending when the beneficiaries of such spending are of a different race. Luttmer (2001) finds some evidence for this reasoning in the United States. In a similar fashion, ethnic diversity may also affect municipal borders. If voters dislike interacting with people of different ethnic backgrounds, they may choose more homogeneous towns.

The goal of this chapter is not to review the whole literature on the subject of diversity and public goods. For a more exhaustive survey, one should consult the reviews of Alesina and La Ferrara (2005), and Stichnoth and Van der Straeten (2013). Important contributions include that of Alesina, Baqir, and Easterly (1999), who find that ethnic fragmentation in local jurisdictions leads to a lower provision of productive public goods. Similarly, Luttmer (2001) uses micro-data in the United States to show that preferences for welfare spending depend on the race of others in their neighbourhood. In particular, people increase their support for welfare spending when the share of welfare recipients in their own race group increases. The author notes that race in itself is not the driver of his results. The identification of individuals to this group is the driving factor. In fact, the result could be replicated using, for example, religious groups, if these are important to the community. In the case of Québec, language should be an important defining characteristic.

Other papers looking at diversity and local public goods include one by Alesina and La Ferrara (2002), who find that higher levels of heterogeneity in race and income in a community are associated with low levels of interpersonal trust in that community. More recently, Algan, Hémet and Laitin (2016) use a natural experiment in France to show that the quality of local public goods depends negatively on the diversity among adjacent neighbourhoods. Li (2010) studies national public goods, but finds that ethnic heterogeneity in a country lowers "tax morale," such that tax collection is costlier, in turn affecting the performance of the public sector.

Lind (2007) and Flamand (2015) make arguments similar to the one in this chapter, but on the subject of redistribution. Flamand (2015) argues that redistribution is hindered in centralised economies when group loyalty is important, since richer individuals are less likely to support it. In that argument, the focus is on the fact that individuals are more altruistic towards people of their own ethnic group. This argument is also supported by the findings of Fong and Luttmer (2009, 2011) on how race affects charity donations. Similarly, in experimental economics, a large number of papers, including those Chakravarty and Fonseca (2012) and Ahmed (2007), show that individuals show preferences for people of their own group. These results also relate to the theory of social identity, developed by Tajfel and Turner (1979) and, more recently, by Akerlof and Kranton (2000).

In this chapter, I argue that if individuals are altruistic towards their own ethnic group (i.e., exhibit group loyalty), they will more readily accept their town being merged with towns of similar ethnic composition. Indeed, merging usually translates in a modification of the local government policies, since it changes the composition of the voting population. For example, the new merged town may include poorer people with different public policy priorities. These compromises in public spending should be more readily accepted, and the merger supported, if the merged town is homogeneous on the ethnic dimension, in the same way that rich people accept greater welfare spending when the recipients are of the same ethnic group (as in Luttmer, 2001).

3.3 Institutional Context: Municipalities in Quebec and the Rules Governing the Referendums

In 2000, there were around 1300 municipalities[6] in the Canadian province of Quebec. Out of those municipalities, only five counted more than 100,000 inhabitants, while 552 included less than 1,000. The Census Metropolitan Agglomeration (CMA)[7] of Montreal, the largest city in the province, included over 100 municipalities (with about half of the provincial population). In that CMA, but also across the province, one concern of the provincial government was the disparity in tax rates between the core city and the periphery. In their *White Book* that preceded the reform, the provincial government writes that in Montreal, property taxes amounted to 2.12 dollars per 100 dollars of property evaluation, while they amounted to 1.88 dollars on average in the periphery municipalities (Government of Quebec, 2000).

As in many places around the world, politicians (both at the municipal and provincial levels) were discussing the possibility of municipal mergers in order to provide public services more

[6]Municipalities in Quebec include towns, cities, villages, etc. In this chapter, I will use these terms interchangeably, as my focus is not on the differences between these categories.

[7]A statistical area defined as the main city along with all fringe municipalities to which it is closely integrated

efficiently. While some municipalities willingly decided to merge, the provincial government decided to merge other municipalities without consulting citizens. In particular, in 2001, it created in this way 42 new municipalities out of 213 towns. The mergers were very different in size, ranging from only 2 towns to 26 of them in Montreal, and from about 600 individuals to over 1.8 million in population.

In some of these mergers, part of the population disapproved of this policy. When a new government was elected in 2003, they promised to hold a referendum in every municipality that was merged without consultation. This new government kept its promise, and put in place a process to hold secession referendums in 2004 for all of the 213 ex-towns that were part of the wave of forced mergers. This section will describe the referendum process in detail, after providing some broader institutional context for those referendums.

Municipalities in Quebec are responsible for a range of local public services. These services include police and fire protection, local roads, water treatment and waste management, libraries, parks, cultural events, urbanism, public transport, and local economic development. To provide these services, municipalities collect a property tax as well as service fees (e.g., for public transport). They may also receive transfers from higher levels of government. Of particular interest to this chapter is that these transfers depend on population size. In fact, the provincial government argued in their *White Book* that municipalities avoided merging on their own specifically to avoid losing transfers once they passed to 5,000 population mark (Government of Quebec, 2000:22). In that case forced mergers seemed like a good solution.

Even before 2001, governments have realized the need for some regional cohesion in public services provision. Especially in more rural regions, municipalities are grouped by region in "counties" or MRC (in French: Municipalités régionales de comté). The governments of these MRC are composed of politicians from the constituent towns, instead of being directly elected by the general population. In the three largest urban areas (Montreal, Quebec, Outaouais), there were, before 2001, similar arrangements although with different names. Still, some politicians pushed for greater collaboration, and in 2001, the provincial government decided to go ahead and organize the wave of mergers described above. It created single municipalities for the largest agglomerations in the province, and created mergers from other smaller municipalities across the territory.[8]

[8] A map of mergers can be found on the website of the provincial government, in French, at http://www.mamrot.gouv.qc.ca/pub/organisation_municipale/cartotheque/Projet_loi_9.pdf.

Since the mergers were done without public consultation, citizens in many towns felt slighted by the government. Keen to capitalize on that public anger, the opposition party decided to campaign, in the 2003 provincial elections that followed, on the idea of organizing referendums in every town merged without consultation. They eventually won the election, and a year later, announced the rules for these consultations.

These rules were as follows. To have a referendum, ten per cent of the voters registered in the previously-existing town had to sign a public register. Out of the 213 municipalities included in the merger wave, 89 met that condition. Then, for the referendum to be successful, at least 35 per cent of registered voters had to cast a vote in favour of secession (thus introducing a minimum participation criterion). Furthermore, for separation to occur, at least 50 per cent of votes cast plus one had to be in favour of separation. Out of the 89 referendums organized in the province, 31 met both criteria and were re-constituted.[9] If there had been no minimum participation criterion, almost twice as many towns would have seceded (58 of them voted in favour of secession including those in which turnout was too low).

In the agglomerations where there was at least one re-constitution, a new governance structure, an agglomeration council, was put in place (this structure was planned before the referendums, and known by voters). Therefore, a positive answer to the referendum did not lead to a complete severing of the ties between the reconstituted town and the agglomeration. The agglomeration council is constituted of representatives from the central municipality (the part of the merger left unchanged by the referendums) and towns that were re-constituted, in proportion to their respective populations. The agglomeration (through the central municipality) is responsible for services including police, fire protection, municipal courts, water purification and distribution up to the local systems, maintenance of main roads, tourism, and elimination of waste. Re-constituted towns keep local services such as libraries, the urbanism plan and delivery of construction permits, local water distribution, local waste collection, local roads, and sports and culture installations. A special arrangement was also planned for Montreal. In that city, a number of boroughs ("arrondissements") were created to oversee neighbourhood services in places that had not separated. However, these sub-governments function mostly with transfers from the central municipal government.[10]

[9] When only some of the towns in a merger successfully secedes, the other towns part of the same merger stay merged.

[10] Some of them levy special local taxes, or fees for specific services. However, these are minor compared to municipal taxes.

3.4 Data and Empirical Strategy

In an earlier section, we saw how municipal consolidations can be difficult to analyse empirically. Fortunately, the sequence of events that led to the referendums in Quebec simplifies the analysis. Two features of the data explain how my analysis can rely on simpler methods. First, in contrast to municipal mergers elsewhere, in Quebec they were imposed by a higher level of government in an authoritarian fashion, instead of decided by local officials. Second, voters had to decide between only two options: either they accepted or opposed the already-realised merger. For these reasons, and due to the observations being at the level of pre-merger towns, I do not need to account for the problem of two-sided decisions described earlier. Another advantage of the dataset in this chapter is that it allows an analysis of voter decisions, instead of relying on the choices of governments.

The results from these public consultations[11] thus provide a relatively large dataset of votes for or against de-mergers. Furthermore, these data can be combined with data from the 2001 Canadian Census Community Profiles (at the Census Sub-Division level) to obtain a detailed socio-economic portrait of every town before the merger events. This section describes the empirical methods and describes the data and variables included in the analysis.

3.4.1 Dependent Variable

The dependent variable in the analysis is the results of the referendums in each pre-merger town ($N = 213$). I choose a binary variable indicating the outcome of the consultation process, constructed as such:

$$\text{Separation} = \begin{cases} 0 & \text{if a town stayed in the merger} \\ 1 & \text{if a town seceded} \end{cases}$$

For example, if a town does not gather the 10 per cent of signatures required for a referendum, the dependent variable would be equal to 0. The definition of this variable implicitly assumes that if a town did not manage to gather the number of signatures required, the referendum would have failed if one had been held.[12]

[11]Available from the Ministry of Municipalities, at http://www.mamrot.gouv.qc.ca/organisation-municipale/historique/consultation-sur-la-reorganisation-territoriale/registres/, and from Elections Quebec, at http://www.electionsquebec.qc.ca/english/tables/result-referendum-2004.php.

[12]However, there are several other possible ways to measure the results. Appendix 3.6.4 presents results using a categorical variable. Another definition is the share of votes in favour of secession in the referendum. However, that variable only exists in the 89 municipalities that actually had a referendum, so the econometric estimations

In the analysis below, I estimate a simple linear probability model (i.e., OLS), as well as a more sophisticated Probit model. The electoral results are provided by Quebec's General Director of Elections. I estimate both models with robust standard errors clustered by merger. For the Probit estimations, unless noted otherwise, I report the marginal effects

3.4.2 Description of the Independent Variables Included in the Analysis

For the socio-economic data, I collect data from the most recent Canadian Census that took place before the merger wave (namely, the 2001 Community Profiles at the level of Census Subdivisions), as well as data from the Ministry of Municipalities (data on municipal budgets) and Elections Canada (federal election results). I use these data to paint a portrait of each town involved in the merger wave, before it took place.[13] The choice of variables is driven by the theory on secessions and previous empirical analyses of municipal mergers, as described above.

Socio-Economic Characteristics

First, I include variables that may capture differences in the preferences for public goods. As in earlier papers, I thus include differences in income, language, etc. These characteristics may indeed be correlated with preferences for public goods.[14] The analysis in this chapter will focus mostly on income and language, but robustness tests will include heterogeneity in other characteristics such as education levels.

To measure income differences between a pre-merger town and its merging partners, I calculate the following variable for each town i in a merger with towns $j \in \{1, ..., n\}$:

$$\textit{Diff. Median Income}_i = \left| MedianIncome_i - \frac{\sum_{j \neq i} Population_j \cdot MedianIncome_j}{\sum_{j \neq i} Population_j} \right|$$

This variable captures the degree to which a town differs from the others in the same merger in terms of median income.[15] Since it is in absolute value, it will take the same value for a richer and a poorer town, only capturing the degree of heterogeneity between a town and the rest of the merger. In the analysis, I also include an indicator variable equal to 1 if the town

would suffer from sample selection. It is possible to solve this problem using a sample selection model, but the main analysis would still only include 89 data points. Tanguay and Wihry (2008) chose to use this method.

[13] Data are missing for some of the 213 municipalities, so estimations actually include fewer observations. See Table 3.2 for details.

[14] See Appendix 3.A for some results on the correlation of socio-economic characteristics and the level of spending, both for all municipalities in Quebec and restricted to those in the sample.

[15] More precisely, I use individual total income.

has a lower median income than the average of median incomes in the agglomeration. This variable should help understand whether there is a "rich town effect," according to which richer communities are the ones opting for secession.

Since taxes at the municipal level are applied on house values, and not income, it may be interesting to include differences in house values instead of median income. In fact, controlling for differences in the value of the tax base (i.e., house values) may help isolate the *preferences* effect of income differences from a *tax base* effect. More specifically, we could suspect that rich towns (often on the periphery) might oppose mergers to avoid tax increases, for example. For this reason, I create a variable similar to the one for income, but instead using the average value of houses in each pre-merger town. However, I do not calculate that variable in absolute value, since I want to capture whether rich towns (in terms of the tax base) are the ones seceding.[16]

To measure the differences in language composition, I take the same approach, with the percentage of English speakers in each town:

$$\textit{Diff. \% English-Speaking}_i = \left| ShareEnglish_i - \frac{\sum_{j \neq i} Population_j \cdot ShareEnglish_j}{\sum_{j \neq i} Population_j} \right|$$

This variable captures the difference between the share of English-speakers in the municipality and the weighted average share in the rest of the merged agglomeration. I also include an indicator variable equal to 1 if the share of English speakers is larger in the town than in the merger (i.e., the town is more English-speaking than the average of its partners in the merger).

In addition to income and language, I also include data, constructed in a similar way, on the percentage of university-educated people, visible minorities, recent migrants (past 5 years) from elsewhere in the province, as well as on the unemployment rate and inequality (measured crudely by the ratio of average to median income). These variables all account for some potential preference heterogeneity between individuals of different municipalities.

Control Variables

In Quebec, political parties are mostly absent from local politics, except in bigger cities in recent years. For that reason, it is virtually impossible to compare the political alignment of local politicians in different cities. However, it is still possible that voters in different cities have different political preferences, more generally. Moreover, these preferences are probably

[16]In the interest of completeness, robustness checks indicate that in absolute value, this variable has no effect on probability to secede. Results are not reported, but are available from the author.

highly correlated with other characteristics such as language composition. Therefore, I control for political preferences using electoral results at the *federal* level, in each pre-merger town.

First, I take voting results at the level of voting district[17] in the 2000 federal elections, which took place before the merger events. These data are available from Elections Canada. Then, I aggregate these results by pre-merger town to obtain the political preferences of each town. In Quebec in 2000, two federal parties dominated the results: the Bloc Quebecois and the Liberal Party.[18] To measure the differences in political preferences between a pre-merger town and its merging partners, I calculate the following variable, with $\%BQ$ the share of the vote going to the Bloc Quebecois:

$$\textit{Diff. \% BQ}_i = \left| \%BQ_i - \frac{\sum_{j \neq i} Population_j \cdot \%BQ_j}{\sum_{j \neq i} Population_j} \right|$$

Differences in preferences for public goods could translate in different levels of spending in pre-merger towns. Therefore, differences in the spending level between municipalities could affect the probability of municipal secession. In addition, these differences are likely to be correlated with income differences, for example. To measure differences in spending levels, I use financial data from municipalities in 2001, before the mergers, on total public spending. I then calculate a variable similar to the ones for income and language, using the total amount of spending per capita:

$$\textit{Diff. Public Spending}_i = \left| SpendingPerCapita_i - \frac{\sum_{j \neq i} Population_j \cdot SpendingPerCapita_j}{\sum_{j \neq i} Population_j} \right|$$

It is also possible that the differences in public goods preferences are completely captured by the previous variables (e.g., language and income). In that case, I might not find

Any discussion of public spending is incomplete without a discussion on taxes (or revenues). Voters may be more reluctant to vote for secession if they expect tax increases (all else being equal). Tax increases could reflect the loss of economies of scale due to the smaller size of the re-constituted town. However, variations can also reflect, for example, debt incurred during the period in which the merger existed that will become the responsibility of a re-constituted town (if that debt was incurred for local goods). Nevertheless, that variable could play an important role in the voters' decision, and should be included in the analysis if possible.

[17] Each electoral riding at the federal level, which includes several towns, is made up of a large number of voting districts.

[18] On average, in my data, these two parties together represent 87% of the municipal vote share.

Fortunately, when it organized the referendums, the central government also mandated private consultant firms with the task of estimating the tax increase or decrease that an average household would experience in the re-constituted municipality. In doing so, these firms estimate how much an average voter would pay in tax to the agglomeration (basically the central town still responsible for part of the public goods) and to the re-constituted town (including referendum and transition costs, debt sharing, and re-assignment of current spending to re-constituted towns), and calculated the difference between that total and the taxes paid before the referendum. These estimates are certainly imperfect, but they were made available to all voters before the referendums. In my estimations, I use the estimated tax increase or decrease predicted after five years, in percentage.[19]

So far, the discussion in this section focused on one side of the traditional trade-off between closeness of preferences and economies of scale. It can be more difficult, however, to analyse the impact of potential economies of scale on voting for secession. Larger municipalities may benefit more from economies of scale, but population size is only an imperfect measure (two towns of the same size may have different abilities to benefit from these economies of scale). In any case, the process governing the reconstitution of former towns is such that even when secession takes place, citizens in seceded towns still benefit from economies of scale, since some public goods are to be provided by the central city. Despite these considerations, the analysis will include some variables controlling for the size of jurisdictions.

First, I simply include the population of every pre-merger town. Second, I calculate the share of the agglomeration's population for each constituent town. Third, I include the size of the largest town in each merger. The last two variables may control for the loss of representation that might be experienced by a smaller town merged with other larger towns.

The geographical distance between the municipality and the merger's central town may also influence the choice of voters. This variable may have effects both on efficiency gains and on the heterogeneity of preferences. Indeed, as municipalities are farther away, their needs may differ. Efficiency gains are also probably lower, because public services have to be delivered in a larger geographical area. Both explanations point in the same direction: a more distant town should be more likely to secede from the agglomeration. I calculate distance using the

[19] More details on these studies are available, in French, at the following address: http://www.mamrot.gouv.qc.ca/organisation-municipale/historique/consultation-sur-la-reorganisation-territoriale/etudes/.

geographical location (latitude and longitude)[20] of every town in my sample, and measuring the distance between each pre-merger town and the location of the core municipality of the merged agglomeration.[21] In addition to distance, I also include population density to account for the rural, urban or suburban composition of the municipalities.

Table 3.2 provides summary statistics for the variables described in this section.

Table 3.2: Summary Statistics

	N	Mean	Std. dev.	Minimum	Maximum
Secession	213	0.146	0.353	0	1
Turnout in Referendum	89	53.357	11.494	31.010	98.000
% of Yes Votes in Referendum	89	32.213	13.695	10.500	74.000
% of Signatures in the Register	213	10.643	12.459	0.000	79.167
Diff. Median Income (thousands)	204	3.649	3.344	0.046	18.156
Diff. % English-Speaking	211	5.514	10.894	0.008	83.906
Larger Proportion English-Speaking	211	0.469	0.500	0	1
Poorer than merging partners (in median income)	204	0.422	0.495	0	1
Median Income	207	21811.627	4838.157	11591	38537
Diff. House Values (thousands)	211	4.386	50.476	-181.745	387.626
Diff. % of Votes for Bloc Québécois	206	6.159	6.913	0.001	35.693
Delta Public Spending per Capita (thousands)	206	0.521	0.992	0.003	9.500
Tax Impact (5 years)	210	7.440	16.430	-37.100	94.000
Distance to core city	209	12.356	15.602	0.000	165.147
Population Density	212	746.525	1294.063	0.150	7551.942
Population in 2001	212	19835.307	74228.950	35	1039534
Share of merger population	212	19.811	24.190	0.054	95.481
Size of Largest Town in Merger (thousands)	213	172.694	340.808	0.402	1039.534
Diff. Median Age	209	3.012	2.141	0.003	12.308
Diff. Unemployment Rate	211	3.397	4.082	0.080	28.912
Diff. % of Visible Minorities	211	2.064	3.932	0.000	21.071
Diff. % University-Educated	208	6.229	6.557	0.062	34.452
Delta Recent Intra-Provincial Migrants	208	4.387	4.170	0.014	20.656
Delta Inequality (Average over Median Income)	201	0.110	0.099	0.001	0.679

3.4.3 Estimation Strategy and Hypotheses

With the variables described above, I estimate equations based on the following (for OLS):

$$\begin{aligned} Secession_i = \beta_0 &+ \beta_1(Diff.\ Median\ Income_i) + \beta_2 I_i(Poorer) \\ &+ \beta_3(Diff.\ \%\ English\text{-}Speaking_i) + \beta_4 I_i(More\ English\text{-}Speaking) \\ &+ \mathbf{x_i} \cdot \gamma + u_i \end{aligned}$$

[20] The geographical location of a municipality is approximated by its centroid.

[21] While the core municipality is often in the geographic centre, it is not always the case. The core municipality is identified in government documents, and is usually the one including the business core. In rare cases where it was not clearly identified, I assume that the largest town in terms of population is the core municipality.

where $I_i(\cdot)$ represents the indicator function (takes values 1 or 0) for observation i. Estimations will differ by the control variables included in $\mathbf{X}$ and the estimation method (OLS or Probit). I am interested in the effects of language and income differences on the decision to secede. Based on the literature on secessions (e.g., Alesina and Spolaore, 1997), I will test the following hypotheses.

Hypothesis 3.1. *Larger differences in income between a town and the rest of the merger increase the probability that the town secedes. In addition, richer towns have a greater probability of secession.*

Hypothesis 3.2. *Larger differences in language between a town and the rest of the merger increase the probability that the town secedes. In addition, more English-speaking towns have a greater probability of secession.*

Indeed, I expect a positive effect of these two variables on secession. As voters experience more heterogeneity in the merged jurisdiction, they will prefer to secede. Intuition would also predict that towns that are more English-speaking than the average of the other towns in the merger would secede more, and that towns that are poorer (richer) would secede less (more).

Median income could capture two distinct effects: richer periphery towns want to secede to avoid facing higher tax rates, and people of different incomes are likely to have different priorities concerning public goods. Since the tax rates in the sample municipalities are defined on the value of houses, I could measure the effect of income differences net of the "tax base effect." First, I expect that towns with larger average house values are more likely to secede, to avoid higher tax rates.

Hypothesis 3.3.A. *Towns with larger house values than the rest of the merger secede more often.*

Second, I expect the effect of income differences to be robust to the addition of differences in house values, thus capturing the preferences effect.

Hypothesis 3.3.B. *The effect of income differences is robust to the addition of differences in house values.*

Explaining the Effect of Diversity: Interaction Terms

If I find a significant effect of differences in socio-economic characteristics on votes for secession, there are at least two possible explanations for it. One is that these differences translate into differences in preferences for public goods. The other (possibly complementary) explanation is that voters care about the identity of people living in their jurisdiction. To investigate this second possibility, I will refine the analysis using interaction terms between the two variables of income and language differences. If voters vote according to some group loyalty component, the effects of language and income differences should depend on one another. The main idea behind this argument is that if people identify with others according to one dimension (say, language), they would be more willing to compromise on preferences related to other dimensions (say, income) when grouped with similar people in terms of their identity.

In this chapter, I argue that language is an important group marker, given the importance of that characteristic in Canada, and especially in Quebec. The territory of Quebec was colonized by both the French and the English more than 400 years ago, and is still characterized today by the co-existence of these two language groups. Although violent conflict mostly disappeared today, some animosity still exists between them, and people still identify (to different degrees) with their linguistic group (Thomson, 1995; Edwards, 2009). Moreover, debates regularly take place on the validity of the language laws in place to protect the French language (e.g., on the size of French writing on commercial signs). In 1980 and 1995, the province itself organised two referendums to secede from Canada, and language was an important aspect of the secessionist movement.

Interaction Terms

Therefore, in the first estimations, I include an interaction term between income and language differences, both defined as in the previous section.

$$
\begin{aligned}
Secession_i = \beta_0 &+ \beta_1(\textit{Diff. Median Income}_i) + \beta_2(\textit{Diff. \% English-Speaking}_i) \\
&+ \beta_3(\textit{Diff. Median Income}_i) \cdot (\textit{Diff. \% English-Speaking}_i) \\
&+ \beta_4 I_i(\textit{Poorer}) + \beta_5 I_i(\textit{More English-Speaking}) \\
&+ \mathbf{x_i} \cdot \gamma + u_i
\end{aligned}
$$

If I do not find a significant interaction term, then preferences alone might explain the result. However, if I do find a significant interaction term, preferences alone could not explain the results. Instead, it would suggest that voters exhibit group loyalty. In summary, I test the following hypothesis:

Hypothesis 3.4. *There is a significant and positive interaction effect between income and language differences.*

A positive interaction term reflects the fact that voters in towns merged with partners similar on one dimension (e.g., small differences in language) should be more willing to compromise on a second dimension. Therefore, the effect of the latter dimension on the probability of secession would be lower at small levels of the former.

Threshold Effects

Another way to look at this question is by using threshold values for language (income) differences, to test whether the effect of income (language) differences is different below and above the threshold. To do so, I split the cities in categories using two binary variables. The first equals 1 if the town is characterized by small language differences, and 0 otherwise (I will refer to this variable as the small language differences indicator). The second is calculated similarly, but using income differences (I will refer to this variable as the small income differences indicator). Defining the cut-off for large or small differences is not obvious, so I use two definitions for robustness. In particular, I define the cut-off either at the average or median difference for the variable of interest for the whole set of observations.[22] Using these two indicator variables, I estimate two additional models.

In the first model, I include income differences as defined in previous sections (continuous variable), but instead of the continuous language differences, I include the small language differences indicator. The model then includes an interaction term between that dummy variable and the continuous income differences variable.

$$\begin{aligned} Secession_i = \beta_0 &+ \beta_1(\textit{Diff. Median Income}_i) + \beta_2 I_i(\textit{Small Language Diff.}) \\ &+ \beta_3(\textit{Diff. Median Income}_i) \cdot I_i(\textit{Small Language Diff.}) \\ &+ \beta_4 I_i(\textit{Poorer}) + \beta_5 I_i(\textit{More English-Speaking}) \\ &+ \mathbf{x_i} \cdot \gamma + u_i \end{aligned}$$

That model will allow a comparison of the effect of income differences between two groups of cities: those with large differences in language and those with small differences.

[22] For income differences, the mean is 3.65 thousands and the median 2.81 thousands. For language differences, the mean is 5.51 percentage points and the median 1.08 percentage points.

The second model will include language differences as a continuous variable, but instead will include income differences as a dichotomous variable: large or small income differences, as defined earlier.

$$\begin{aligned}
Secession_i = \beta_0 &+ \beta_1 I_i(\textit{Small Income Diff.}_i) + \beta_2(\textit{Diff. \% English-Speaking}_i) \\
&+ \beta_3 I_i(\textit{Small Income Diff.}_i) \cdot (\textit{Diff. \% English-Speaking}_i) \\
&+ \beta_4 I_i(\textit{Poorer}) + \beta_5 I_i(\textit{More English-Speaking}) \\
&+ \mathbf{x_i} \cdot \gamma + u_i
\end{aligned}$$

That model will allow a comparison of the effect of language differences between cities in the two categories. Tajfel and Turner (1979) argue that people may create their social identity along many dimensions. Akerlof and Kranton (2000) make the same argument. For that reason, I could find a group loyalty effect in both dimensions. I thus make the following hypothesis:

Hypothesis 3.5. *The effect of income (language) differences on the probability to secede is simaller in towns that have small language (income) differences.*

If voters identify more with others along one dimension (say, language), it is possible that I find asymmetric effects.

3.5 Results

Before proceeding with the regression estimates, Figure 3.1 provides a closer look at one of the mergers: the island of Montreal (all included in the Montreal merger), with the constituent ex-municipalities colour-coded according to their median incomes and proportions of English-speakers. The map also depicts the voting results in each town.

This figure shows that first intuitions are somewhat true: richer and English-speaking towns seceded in greater numbers. However, the map also highlights that some richer towns may be willing to stay in the merged city, especially when other characteristics such as language are not too different (e.g., Outremont). Also, on the island of Montreal, one secession took place in a relatively poor francophone city.

In Montreal, the map shows that the proportion of English-Speakers is somewhat correlated to median incomes. However, province-wide, the correlation coefficient between these two variables is only equal to 0.12. Moreover, Table 3.3 shows that towns that have a lower median

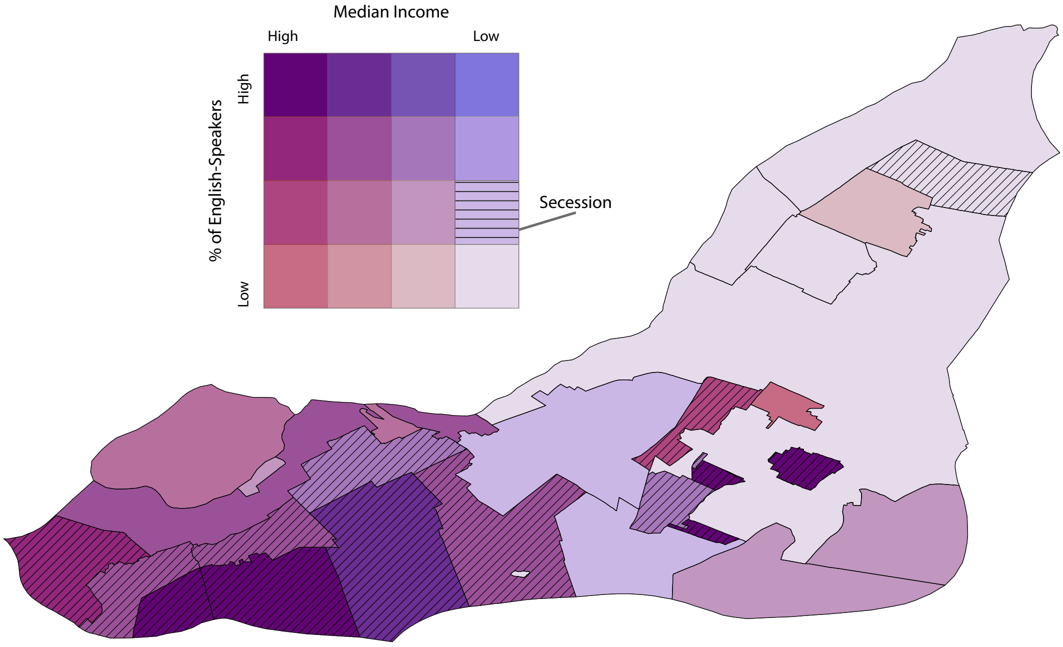


Figure 3.1: Referendum Results in Montreal

income than the rest of the merger can be either more English-speaking or less.

Table 3.3: Number of Cities of the Sample, by Relative Income and Language

	Less Anglophone	More Anglophone
Higher median income	61	57
Lower median income	47	39

3.5.1 Determinants of De-Merger Votes

The regression results confirm the relationships shown in Figure 3.1. Results from OLS estimations and marginal effects from the Probit estimations are shown in Table 3.4. I find that both income and language differences affect the choice of citizens.

Language Differences

First, towns that have a greater proportion of English-speaking people than the rest of the merger have a probability to secede that is about 9 percentage points higher. Furthermore, even accounting for that effect, the *level* of language differences also plays a role. In particular, an increase of 1 percentage point in the language differences variable is associated with an

Table 3.4: Determinants of De-Mergers: OLS and Probit Estimations

	(1) OLS	(2) OLS	(3) OLS	(4) Probit M.E.	(5) Probit M.E.	(6) Probit M.E.
Diff. Median Income (thousands)	0.0221***	0.0191**	0.0124*	0.0132**	0.0133***	0.0098**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Diff. English-Speaking Proportion	0.0138***	0.0115***	0.0062**	0.0071***	0.0042**	-0.0004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Larger Proportion English-speaking	0.0981***	0.0966***	0.1095***	0.0809**	0.1004***	0.1034***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
Poorer than merging partners	-0.0556*	-0.0096	-0.0159	-0.0390	-0.0186	-0.0429
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Diff. % of Votes for Bloc Québécois			0.0132*			0.0085***
			(0.01)			(0.00)
Diff. House Values			0.0008			0.0006
			(0.00)			(0.00)
Diff. Public Spending per Capita		0.0509	0.0480		0.0346	0.0356**
		(0.06)	(0.05)		(0.02)	(0.02)
Tax Impact (5 years)		-0.0047**	-0.0046***		-0.0048***	-0.0043***
		(0.00)	(0.00)		(0.00)	(0.00)
Distance to core city		-0.0014	-0.0014		-0.0031*	-0.0008*
		(0.00)	(0.00)		(0.00)	(0.00)
Density		-0.0000***	-0.0000***		-0.0000*	-0.0000
		(0.00)	(0.00)		(0.00)	(0.00)
Population		-0.0000	-0.0000		0.0000	0.0000
		(0.00)	(0.00)		(0.00)	(0.00)
Share of Merger Population		-0.0030**	-0.0029**		-0.0038***	-0.0030***
		(0.00)	(0.00)		(0.00)	(0.00)
Size of Largest Town in Merger (thousands)		0.0002**	0.0001		0.0001	0.0000
		(0.00)	(0.00)		(0.00)	(0.00)
Constant	-0.0456	0.0505	0.0263	n.a.	n.a.	n.a.
	(0.03)	(0.05)	(0.05)			
N	204	194	194	204	194	194
R^2 (*Pseudo-*)	0.405	0.496	0.537	0.400	0.581	0.643
F-test/χ^2-test (*p-value*)	0.000	0.000	0.000	0.000	0.000	0.000

Note: For OLS, clustered (by merger) robust standard errors in parentheses. For Probit, marginal effects are reported, with robust standard errors (unconditional) in parentheses. Probit estimations themselves calculated using clustered standard errors (by merger). Significance levels: *** 1% ** 5% * 10%

increase in the probability of secession of between 0.4 and 1.4 percentage points. This effect is present in almost all models presented, and statistically significant at the 1% or 5% level, depending on the model.

Result 3.1. *Towns with a greater proportion of English-speakers are more likely to secede from the merger. Furthermore, the probability of secession is positively affected by the absolute level of differences in language composition between a city and its merging partners.*

This effect is robust in OLS estimations to the inclusion of differences in political preferences. However, it is not robust to that inclusion in the Probit estimations (Column 6, Table 3.4). This finding suggests that political preferences are correlated with language, such that the two variables capture a similar effect. In fact, in my data, the share of English-speakers in a given town and the share of votes going to the Bloc Québécois in 2000 are correlated with a coefficient of about -0.6, suggesting that it is indeed the case that political preferences and linguistic composition are intrinsically linked. That being said, the main interest of my investigation is not language composition *per se*, but the attachment of voters to a social identity or ethnic group. The question, then, is whether differences in political preferences in this sample captures the same effect as language differences.

In Quebec, one of the main federal parties (the Bloc Québécois) is a nationalist party, existing to promote the independence of the province of Québec, an option popular mostly (if not only) among French-speaking voters. Since the sovereigntist movement in Québec is strongly linked to language, political results in that province probably don't capture political preferences as commonly understood (on a left-right axis). In fact, Nadeau, Guérin and Martin (1995) argue that the main cleavage in Québec politics[23] was according to "the national question," instead of more traditional questions such as the role of the state.

If votes at the federal level are driven by support for the provincial secessionist movement, which is itself fuelled by linguistic differences, then my variable for political preferences and that for linguistic differences might indeed capture the same underlying effect: attachment to one's ethnic group (in this case, linguistic). Moreover, the coefficient on differences in political preferences is positive and significant, both in OLS and Probit estimations. Both results point in the same direction: greater differences lead to more secessions. In fact, this result suggests that it is indeed not language *per se* that drives the results, but some loyalty to the ethnic

[23]Their paper studies the 1993 elections, but the Bloc Québécois remained popular in the province at least until 2008

group. Without a better indicator of true political preferences (e.g., left-right), I cannot know if differences in this variable would affect the choice to secede.

Income Differences

Differences in median income between a city and other towns in the merger are also associated with an increase in the probability of secession.[24] An increase of a thousand dollars in the absolute earnings difference is associated with an increase of about 1 to 2 percentage points in the probability of secession, depending on the model considered.

Interestingly, while income *differences* seem to affect the probability to secede, being poorer than the rest of the merger has no impact (except in the OLS estimation without any control variable).[25] This result contradicts the commonplace idea that richer jurisdictions are the ones seceding. The fact that only difference between median incomes matter, and not its sign (richer or poorer), suggests that it is preferences resulting from income that are driving the decision to secede, not selfish desires to stop paying for poorer communities.

Result 3.2. *Differences in median income between a city and its merging partners increases the probability that a town will successfully secede. However, richer towns are not more likely to secede.*

I do not find a significant effect of differences in house values on the probability to secede. This result suggests that, at least in my sample, secessions are not driven by rich periphery towns seceding to escape higher tax rates resulting from a merger. When accounting for house values, but not political preferences, I find a significant effect of differences in house values, and the effect of income differences are less significant (Table 3.B.1). However, if house values and political preferences are somewhat related, adding both is preferable.

Result 3.3.A. *Differences in house values do not affect the probability to secede.*

Moreover, these coefficients on income differences are robust to the inclusion of differences in house values. When accounting for that vairable (i.e., differences in the value of the tax base), the effect of income differences is still statistically significant, albeit at a lower level (at the 10% significance level for OLS, but still 5% in Probit).

[24]To control for a potential effect of the scale of the difference variable (differences are larger for towns with higher median incomes), I also estimate the same equations, but with the *Diff. Median Income* variable as a percentage of the town's median income. The results do not change.

[25]Replacing the dummy variable indicating that the town is poorer or richer with simply the level of median income of the pre-merger town does not change these results.

Result 3.3.B. *The effect of income differences is robust to the addition of differences in house values.*

This last result suggests that the effect of income differences is not merely due to a tax base effect.

Table 3.B.1 also presents the results when including merger fixed effects (i.e., a dummy for each merger), as a simple robustness check. I find that differences in income and language still affect the probability of secession. However, due to the large number of variables included in these estimations, the model perfectly predicts some of the results (as illustrated by the reduction in the number of observations in the Probit estimation). Therefore, these specific results may be problematic and are presented mostly for completeness.

Control Variables

In most regressions, I include a number of additional control variables that produce some interesting results. Differences in total spending per capita seem to affect the decision to oppose mergers. However, the coefficient on that variable is only significant in some of the Probit estimations, and at low levels of significance. As expected, however, a predicted increase in taxes after a re-constitution is associated with a decrease in the probability of secession. In particular, a predicted increase in taxes of 1 percentage point is associated with a decrease in the secession probability of approximately 0.4 percentage points. The result is quite robust across models.

Demographic factors also seem to play a role in the decision of voters. Towns that have a larger share of the agglomeration's total population are, unsurprisingly, less likely to secede. That result is robust across models and indicate that an increase of 1 point in the town's share of merger population is associated with a decrease in the probability of secession of around 0.3 percentage points. Density also negatively affects the probability of a town to secede, although this result is significant only in some OLS estimations. This result would indicate that more urban towns are less likely to secede, which is not a surprising observation. For its part, the size of the largest town in the merger is positive and significant only in some of the OLS estimations. While it is not very robust, this result would indicate that voters do resent being lumped with very large towns, who would usually get more say in decisions simply due to their sheer size.

In terms of geography, distance to the core city does not affect the voters' decision. However, this variable is only crudely measured as some towns have very large territories and their centroid does not accurately represent where most of the population resides.

Other Measures of Heterogeneity

Finally, other measures of heterogeneity, such as differences in unemployment or median age, have only limited explanatory power (Table 3.B.1). Indeed, in the OLS estimations, none of the coefficients are significant. In the Probit model, I do find an effect from differences in the share of visible minorities (positive, as expected) and in inequality (negative). The coefficient on differences in inequality warrants some further discussion. Indeed, the negative sign indicates that towns that have different inequality levels (measured as the ratio of average to median income) than the rest of the merger are less likely to de-merge. A further investigation, by eliminating the absolute value on the variable, indicates that it is actually towns with *larger* inequality that are more likely to de-merge. Better measures of inequality would help understand this result, but they are not available at the municipal level.

3.5.2 Interaction Effects: Group Loyalty Matters in the Voters' Decisions

The previous section presented some interesting results on the motivations behind the voters' decision to accept or oppose municipal mergers. However, while it shows that income and language differences are important factors, it does not explain why. As explained earlier, I will rely on interaction terms to offer a deeper investigation.

The first models test whether there is a positive interaction term in the model using continuous variables for both language and income differences. The results are shown in Table 3.5, and do show a positive interaction term between these two variables. In the Probit estimations (Columns 4 and 5, Table 3.5), this interaction effect is robust to the inclusion of the squares of each variable (to account for the potential correlation between the two interacted variables). In the OLS estimations (Columns 1 to 3, Table 3.5), I fail to find a significant interaction term in the simplest model, but I find a positive interaction term (at a 5% significance level) when I add non-linearities in income differences (column 2). Again, this effect is robust to the addition of squared terms for both income and language differences (column 3).[26]

Result 3.4. *The effects of language and income differences positively interact with each other, suggesting the existence of group loyalty effects.*

To better interpret this result, Figure 3.2 shows the marginal effect of income differences on the probability of secession at multiple levels of language differences, using the Probit estimates

[26]The results are also robust to the inclusion of merger fixed effects, as shown in Table 3.B.2.

Table 3.5: Interactions between Continuous Income and Language Variables

	(1) OLS	(2) OLS	(3) OLS	(4) Probit	(5) Probit
Diff. Median Income (thousands)	0.0132	0.0002	-0.0076	0.0575	0.1726
	(0.01)	(0.02)	(0.02)	(0.04)	(0.11)
Diff. English-Speaking Proportion	0.0089*	-0.0002	0.0089	-0.0166	0.0359
	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)
Diff. Median Income * Diff. English-Speaking Proportion	0.0005	0.0039***	0.0048**	0.0229**	0.0208*
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Larger Proportion English-speaking	0.0972***	0.0956**	0.0981***	1.1122***	1.0813***
	(0.03)	(0.04)	(0.03)	(0.39)	(0.34)
Poorer than merging partners	-0.0089	-0.0035	-0.0080	-0.0790	-0.0812
	(0.03)	(0.03)	(0.03)	(0.41)	(0.42)
(Diff. Median Income)^2		0.0008	0.0014		-0.0096
		(0.00)	(0.00)		(0.01)
(Diff. Median Income)^2 * Diff. English-Speaking Proportion		-0.0002**	-0.0002**		
		(0.00)	(0.00)		
(Diff. English-Speaking Proportion)^2			-0.0002**		-0.0010*
			(0.00)		(0.00)
Diff. Public Spending per Capita	0.0556	0.0838	0.0975*	0.5717**	0.5921**
	(0.05)	(0.06)	(0.05)	(0.26)	(0.24)
Tax Impact (5 years)	-0.0046**	-0.0046**	-0.0046**	-0.0491**	-0.0506***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.02)
Distance to core city	-0.0013	-0.0015	-0.0012	-0.0364*	-0.0347*
	(0.00)	(0.00)	(0.00)	(0.02)	(0.02)
Density	-0.0000***	-0.0000**	-0.0000*	-0.0002**	-0.0002*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Population	-0.0000	-0.0000	-0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0030**	-0.0031**	-0.0032**	-0.0452***	-0.0472***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Size of Largest Town in Merger (thousands)	0.0002**	0.0001	-0.0000	0.0002	-0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	0.0699	0.0919	0.0843	-1.5173***	-1.8211***
	(0.05)	(0.06)	(0.05)	(0.46)	(0.49)
N	194	194	194	194	194
R^2 (*Pseudo-*)	0.501	0.513	0.530	0.606	0.620
F-test/χ^2-test (*p-value*)	0.000	0.000	0.000	0.000	0.000

Note: Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%
[a] The F test with fixed effects and clustered standard errors cannot be estimated (not enough information).

(with 95% confidence intervals). The figure shows a positive slope, although the confidence intervals are large at higher levels of language differences. For that reason, the results are more suggestive that there is a cut-off in language differences over which income differences have an effect on voters' choice, instead of a real continuous relationship as stated in the first hypothesis. However, it is clear from the result that voters are more affected by income differences between their town and the rest of the merger when language differences are also present, suggesting the existence of a group loyalty effect.

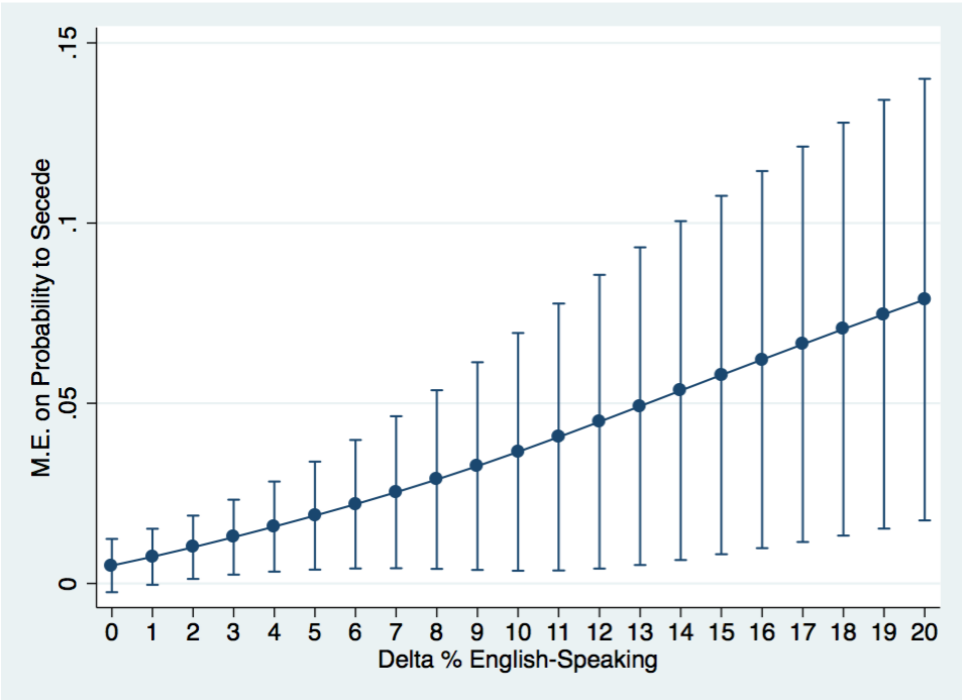


Figure 3.2: Average Marginal Effects of Delta Median Income on Probability to Secede (with 95% Confidence Intervals)

In light of that result, the remainder of the analysis focuses on the thresholds in each dimension (language and income). As explained earlier, I include binary variables that categorise the observations in groups defined by the size of the language or income differences. In the first case, the dummy variable splits the observations in the two following groups: those that have small language differences between them and the rest of the merger, and those that have large language differences.

Looking at Probit estimates, (Columns 1 and 2 of Table 3.6), I find a negative interaction term, but only when using the threshold defined by the mean. In other words, the effect of income differences on the probability of secession is smaller for towns where language differences are small. To facilitate the interpretation of Probit estimates, I also calculate the marginal effect

Table 3.6: Interactions between Income and Language Variables Using Thresholds (Probit Results)

	(1)	(2)	(3)	(4)
Income				
Diff. Median Income (thousands)	0.2062***	0.1528***		
	(0.04)	(0.06)		
Small Income Differences (mean)			-0.5460**	
			(0.25)	
Small Income Differences (median)				-0.1891
				(0.23)
Language				
Diff. English-Speaking Proportion			0.0642***	0.0781***
			(0.02)	(0.03)
Small Language Differences (mean)	-1.4698**			
	(0.60)			
Small Language Differences (median)		-1.2016*		
		(0.69)		
Interaction Language × Income				
Relevant Interaction term	-0.1088**	-0.0186	-0.0269	-0.0509*
	(0.05)	(0.08)	(0.03)	(0.03)
Poorer than merging partners	-0.5521	-0.4684	-0.2905	-0.2494
	(0.42)	(0.42)	(0.39)	(0.38)
Larger Proportion English-speaking	1.2892***	1.3453***	1.0650***	1.0255***
	(0.46)	(0.50)	(0.33)	(0.32)
Diff. Public Spending per Capita	0.4741**	0.4013	0.3899	0.3690*
	(0.22)	(0.28)	(0.24)	(0.22)
Tax Impact (5 years)	-0.0623***	-0.0463**	-0.0536***	-0.0504**
	(0.02)	(0.02)	(0.02)	(0.02)
Distance to core city	-0.0274*	-0.0277	-0.0322*	-0.0372*
	(0.02)	(0.02)	(0.02)	(0.02)
Density	-0.0003**	-0.0002***	-0.0001*	-0.0001*
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0513***	-0.0420***	-0.0455***	-0.0465***
	(0.01)	(0.01)	(0.01)	(0.01)
Size of Largest Town in Merger (thousands)	0.0001	0.0007*	0.0005	0.0004
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-0.3113	-1.2094**	-0.8425*	-0.9845**
	(0.58)	(0.48)	(0.44)	(0.43)
N	194	194	194	194
Pseudo-R^2	0.639	0.584	0.568	0.565
χ^2-test (*p-value*)	0.000	0.000	0.000	0.000

Note: Table reports Probit coefficients. Clustered (by merger) standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.7: Interactions between Income and Language Variables Using Thresholds (OLS Results)

	(1)	(2)	(3)	(4)
Income				
Diff. Median Income (thousands)	0.0484***	0.0361***		
	(0.01)	(0.01)		
Small Income Differences (mean)			-0.0360	
			(0.04)	
Small Income Differences (median)				-0.0100
				(0.03)
Language				
Diff. English-Speaking Proportion			0.0139***	0.0147***
			(0.00)	(0.00)
Small Language Differences (mean)	-0.1151			
	(0.08)			
Small Language Differences (median)		-0.0551		
		(0.05)		
Interaction Language × Income				
Relevant Interaction term	-0.0458***	-0.0293*	-0.0054	-0.0080
	(0.01)	(0.02)	(0.01)	(0.01)
Larger Proportion English-speaking	0.1184***	0.1359***	0.1005***	0.0991***
	(0.04)	(0.04)	(0.04)	(0.04)
Poorer than merging partners	-0.0094	-0.0304	-0.0174	-0.0138
	(0.03)	(0.04)	(0.03)	(0.03)
Diff. Public Spending per Capita	0.0928**	0.0505	0.0623	0.0661
	(0.04)	(0.07)	(0.05)	(0.04)
Tax Impact (5 years)	-0.0046**	-0.0041**	-0.0047**	-0.0047**
	(0.00)	(0.00)	(0.00)	(0.00)
Distance to core city	-0.0005	-0.0017	-0.0015	-0.0017
	(0.00)	(0.00)	(0.00)	(0.00)
Density	-0.0000**	-0.0001***	-0.0000**	-0.0000*
	(0.00)	(0.00)	(0.00)	(0.00)
Population	-0.0000	-0.0000	-0.0000	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0032***	-0.0031**	-0.0030**	-0.0030**
	(0.00)	(0.00)	(0.00)	(0.00)
Size of Largest Town in Merger (thousands)	0.0001	0.0003**	0.0002**	0.0002**
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	0.1932**	0.1105	0.1339	0.1177
	(0.09)	(0.08)	(0.08)	(0.07)
N	194	194	194	194
R^2	0.523	0.466	0.482	0.483
F-test (*p-value*)	0.000	0.000	0.000	0.000

Note: Clustered (by merger) standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

of income differences at the two values of the threshold (i.e., the binary variable). These results are found in the first column of Table 3.8, along with p-values for t tests for the difference between the two. The results show that the marginal effect of income differences is significantly larger in presence of large language differences. Somewhat surprisingly, however, income differences have an effect (but smaller) even with low language differences, although only at a 10% level of significance.

Table 3.8: Interactions between Income and Language Variables Using Thresholds (Probit Marginal Effects)

	(1)	(2)
	M.E. of Income	M.E. of Language
Large Language Differences (mean)	0.0326***	
	(0.01)	
Small Language Differences (mean)	0.0057*	
	(0.00)	
p-value, t-test	0.000**	
Large Language Differences (median)	0.0242***	
	(0.01)	
Small Language Differences (median)	0.0047*	
	(0.00)	
p-value, t-test	0.053*	
Large Income Differences (mean)		0.0067**
		(0.00)
Small Income Differences (mean)		0.0034
		(0.00)
p-value, t-test		0.211
Large Income Differences (median)		0.0076**
		(0.00)
Small Income Differences (median)		0.0026
		(0.00)
p-value, t-test		0.093*

Note: Calculated from the Probit coefficients with clustered standard errors. Robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Columns 1 and 2 of Table 3.7 instead present the results of an OLS estimation of this model. Using both the mean and the median as the cut-off, I again find a negative interaction term, as expected, significant at the 1% and 10% significance level, respectively. Furthermore, the magnitude of the interaction term is virtually equal to the magnitude of the coefficient on the income differences variable, suggesting that in fact, income differences have no effect at small levels of language differences.

In the second model, the threshold is defined using income differences, separating towns in two groups: those with small income differences between them and the rest of the merger, and those with large differences. Columns 3 and 4 of Table 3.6 present the results of Probit estimations of that model. I find a negative interaction term in the equation using the median value as the threshold, but only at the 10% significance level.Columns 3 and 4 of Table 3.7 present the results of that OLS estimation, where I do not find a significant interaction term.

The second column of Table 3.8 summarises the marginal effects of language differences at different values of the binary variables. In this case, I find that these marginal effects are significant only for towns with large income differences. Furthermore, the t-tests are not as conclusive for the difference between the estimates at high and low income differences. Indeed, the difference is only significant at the 10% level and only when using the median as the threshold. To summarize these results:

Result 3.5. *The interaction effects are asymmetric. While the marginal effect of income differences on the probability to secede is strongly affected by the presence of language differences, the opposite is not true.*

3.6 Robustness Checks

Overall, the results using the interaction terms suggest the existence of a group loyalty effect. However, one could potentially offer alternative explanations. In this section, I first investigate the robustness of the interaction effect when including a number of additional variables. Then, I look at alternate definitions of the dependent variable, to better understand how voters decided to secede or not. In particular, I check the importance of the participation criterion.

3.6.1 Interaction Effects with Additional Variables

In Section 3.5, I showed results suggesting that differences in political preferences and house values (i.e., the value of the tax base) also have an effect on the probability to secede. Although political preferences are only imperfectly measured, given the idiosyncratic cleavage in Quebec politics (i.e., federalist-nationalist instead of left-right), it may interesting to determine whether the interaction term is robust to the addition of that variable. Tables 3.B.3 and 3.B.4 show the results this robustness test. In the Probit estimations, the results show that the positive interaction term between income and language preferences is quite robust, especially when including square terms to account for potential collinearity between the interacted variables.[27] In the OLS estimations, I also show that the interaction is robust when including non-linearities in income (as in the previous results of Table 3.5).

As discussed in the previous section, political preferences may capture the same underlying characteristic as language composition. In that case, I should find the same effect when including an interaction term between income differences and differences in political preferences. Column 5 in Table 3.B.4 shows the results of that test with Probit estimation. I do find a positive interaction term between income differences, and differences in the share of votes for the nationalist Bloc Québécois party.[28]

Another possible explanation for the interaction term is that towns with larger differences in language also have larger median incomes, if language and income are correlated. In that case, the larger effect of differences in income at larger language differences would simply result from higher median incomes. That explanation would lead to the same results observed so far. To check if that is the case, I include the level of median income of pre-merger towns directly in the regression. The interaction terms are robust to this inclusion (as reported in Tables 3.B.5 and 3.B.6).

Finally, another possibility is that as differences in language composition increase, so does turnout at the referendums. Indeed, towns with a very different language composition may be more motivated to go vote, thus increasing turnout. Given the referendum rules, and in particular the minimum turnout rule, increased turnout would inevitably lead to a greater probability of secession. Fortunately, I have data on turnout in every town that had an actual referendum. As expected, I find a strongly statistically significant effect of turnout on the probability to secede (see the first column of Tables 3.B.7 and 3.B.8).

Even when controlling for turnout in the regression, I still find a positive interaction between language and income differences. In the Probit results, I find that the interaction is significant even when including the squared variables, as well as differences in political preferences and house values (see columns 2 and 3 of Table 3.B.8). Figure 3.3 shows the marginal effects of income differences at various levels of language differences. This relationship is similar to the one found without including turnout. The OLS results are somewhat less convincing, but I do find a positive interaction term when including non-linearities and differences in political

[27]Without these square terms, the coefficient on language differences is negative. However, since there is some correlation between the two interacted variables, the full model should be superior.

[28]OLS results are not included but show the same positive interaction term.

preferences and house values (at the 5% level, see Table 3.B.7, Column 4), and when accounting for non-linearities alone (at the at the 10% level, see Table 3.B.7, Column 3).

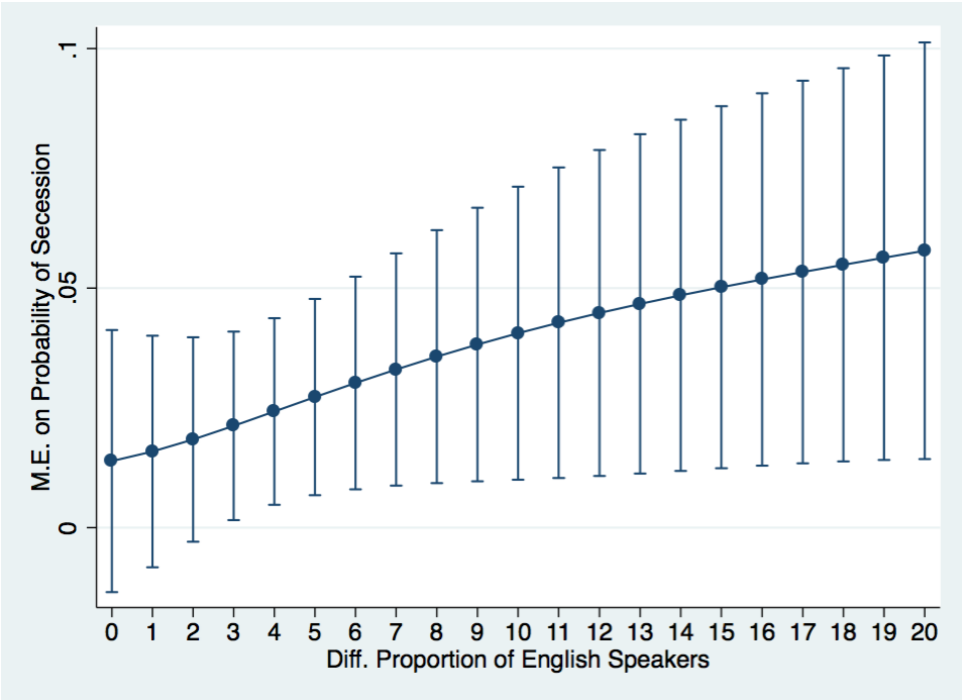


Figure 3.3: Average Marginal Effects of Differences in Median Income on Probability to Secede, with Turnout as a Control Variable (including 95% Confidence Intervals)

Table 3.B.9 presents the results from Probit estimations, for the analysis on thresholds.[29] The results are similar to the analysis without the threshold variable. In particular, the interaction term is significant only in the case of differences in median incomes interacted with a dummy indicating small language differences (with the mean as the threshold). Table 3.B.10 reports the marginal effects. That table shows that the marginal effect of income differences is significantly larger when large language differences are present. This result mirrors the one of Table 3.8, which did not include turnout.

These results are encouraging and suggest that increases in turnout at high levels of language differences does not explain the interaction term completely. However, since the sample size is reduced, the analysis may suffer from a selection problem. To correct for this bias, researchers usually turn to sample selection models, which require a variable that affects selection but not the outcome. In my case, the selection process is clear: towns select themselves into the restricted sample (of having a referendum) by gathering enough signatures on the register. One could reasonably argue that every variable that affects the number of people manifesting their

[29] I do not include the OLS results, but they are similar to the ones obtained with Probit.

desire for a referendum would also affect the support for secession. For that reason, it would be difficult to justify the usage of a Heckman selection model.[30]

Another possibility is to attempt an estimation of the turnout in towns that had no referendum. In fact, in the restricted sample of 89 towns with a referendum, the "turnout" at the registers (i.e., the % of signatures gathered) is highly correlated with the turnout in the referendum (correlation coefficient of 0.67). Using this information, I can estimate a regression with the turnout as the dependent variable, and the percentage of register signatures as an independent variable, along with a set of controls. In turn, I can use these regression estimates to extrapolate the turnout to towns that did not have a referendum. I can then include this estimated turnout in the regression that includes turnout, using in this case the whole sample. In doing so, I again obtain a positive and significant interaction term.[31] This test is obviously not ideal, since it is possible that a town with a low amount of signatures could have a high turnout if, for example, the issue becomes more important during the referendum campaign. However, it provides some support to the finding of a positive and significant interaction term.

3.6.2 Expectations of Secession Votes in Neighbouring Towns

Another possible bias in my analysis is due to potential spatial interactions between voters of different towns in the same merger. Indeed, all referendums took place at the same time, and while the choice was between re-constitution of the previous town or accepting the merger as is, the final configuration of the merger is unknown until all after the referendums. Therefore, choices of voters in a given town could be affected by those of voters in the towns taking part in the same merger.

Since the consultation process took place in two steps, voters had an idea, at the moment of the actual vote, of the popularity of the secession movement in the other towns in the merger. Indeed, the share of registered voters that signed the register is likely a good indication of the amount of support for re-constitution. In this sub-section, I use these data to re-estimate the previous model accounting for these expectations.

[30] One possibility is to use rainfall on the day where registers are open as an instrument, such as in Hansford and Gomez (2010). Unlike regular elections, however, the registers took place over several days (16 to 20 May 2004). Nevertheless, I collected data on total rainfall on these days for every pre-merger town from Environment Canada (`http://climate.weather.gc.ca/advanceSearch/searchHistoricData_e.html`), using geographic coordinates to find the closest weather station to every town. However, unlike for elections, these data do not reliably predict the organisation of a referendum. This result is somewhat expected, since voters actually had 5 days to sign the register. For that reason, it is impossible to reliably estimate a selection model using this variable as the instrument.

[31] Results are not shown but available from the author.

To do so, I will limit the analysis to towns that had a referendum. Those that did not gather enough signatures are not relevant since at the second stage of the consultation, i) they do not make a choice, and ii) there is no uncertainty on their final choice. Reducing the number of towns in the sample inevitably leads to a sample selection problem. However, this sub-section abstracts from this problem, since it was already discussed in the discussion on turnout.

In the first step of the consultation process, voters in the 213 towns had to sign a register. The percentage of registered voters who signed it in each town will stand in for the expected "strength" of the secessionist movement in that town. Voters in every neighbouring town observe that percentage, and can use it when choosing how to vote in the second stage. I will calculate the overall expectations of voters in town i on votes of neighbouring towns in two ways. First, I will calculate the average percentage of register signatures in neighbouring towns simply weighted by population. Note that the sample is reduced only to those towns that had a referendum. Second, I will weight these percentages not only by population, but also by language similarity (i.e., $1 - \left|ShareEnglish_i - ShareEnglish_j\right|$). This second variable will capture the idea that voters in a given town react more to their expectations of votes in towns that are similar to them.

Table 3.B.11 presents the results of Probit estimations when including the weighted averages of register signatures. In these estimations, we report only robust (not clustered) standard errors given the low number of observations and clusters. The interaction term between language and income is, once again, robust to this specification, although only at the 10% level of significance when including all controls.

The results on the average share of register signatures themselves are also interesting. First, note that they are significantly positive in almost all specifications, so that when voters in a given town observe that their neighbours have strong secessionist movements in the first consultation stage, they also are more likely to secede. This effect is also marginally stronger and more significant when using language similarity weights, which would indicate, as expected, a stronger relationship in voting expectations between culturally similar towns.

While these results are interesting, the percentages of voters signing the registers are strongly correlated with the actual referendum results. Therefore, I am essentially estimating a model with a spatial lag. These models are inconsistent when estimated with OLS or Probit.

3.6.3 Spatial Econometrics Results

In this subsection, I provide results from estimations that explicitly account for the spatial correlation between the votes for secession in neighbouring towns using MLE methods. This type of model requires the definition of a matrix of spatial weights indicating the relationship between two towns. I define two such matrices. The first (W) is simply a neighbourhood matrix. Weights for town i take value $1/n_i$ for each n_i town that is part of the same merger as town i. The second matrix (W_{lang}) puts greater weights on towns that are more similar in terms of language composition.

Table 3.9 presents the results of estimations using two models.[32] The first, in columns 1 and 2, is the usual spatial auto-regressive model (SAR), with ρ as the spatial lag:

$$Secession = \rho \cdot W \cdot Secession + \mathbf{X} \cdot \beta + \epsilon$$
$$\epsilon \sim N(0, \sigma^2 I_n)$$

The second model (SEM), in columns 3 and 4, includes spatial dependence in the error term instead, which is captured by the parameter λ:

$$Secession = \mathbf{X} \cdot \beta + u$$
$$u = \lambda \cdot W \cdot u + \epsilon$$
$$\epsilon \sim N(0, \sigma^2 I_n)$$

First, note that the interaction effect between language and income differences is still positive, as in the main results. This result is thus robust to the inclusion of a spatial lag. Second, the spatial lag ρ is also significant, but only when using W_{lang} and only at the 10% level of significance. This finding is consistent with the results using signature registers in Section 3.6.2. Finally, note that λ is statistically significant using both weight matrices, indicating that the data exhibit spatial dependence through the error terms.

3.6.4 Importance of the Participation Criterion

In the results in the main part of the chapter, I consider a binary dependent variable, indicating whether the secession was successful. As such, the coefficients above estimate the effect of the

[32]Both models are estimated with MLE methods in MATLAB using the *sar* and *sem* functions of the Spatial Econometrics Toolbox developed by James P. Lesage.

Table 3.9: Spatial Econometrics Estimations (MLE)

	(1)	(2)	(3)	(4)
ρ	0.133	0.143*		
	(1.571)	(1.678)		
λ			0.173**	0.175**
			(1.968)	(1.997)
Diff. English-Speaking Proportion	-0.00099	-0.00093	-0.00146	-0.00145
	(-0.204)	(-0.190)	(-0.299)	(-0.298)
Diff. Median Income (thousands)	-0.00021	-0.00036	-0.00010	-0.00049
	(-0.010)	(-0.018)	(-0.005)	(-0.024)
Interaction term	0.00398***	0.00393***	0.00409***	0.00409***
	(2.529)	(2.499)	(2.616)	(2.615)
(Diff. Median Income)^2	0.00082	0.00084	0.00081	0.00085
	(0.448)	(0.460)	(0.428)	(0.446)
(Diff. Median Income)^2 * Diff. English-Speaking Proportion	-0.00019**	-0.00019**	-0.00019**	-0.00020**
	(-2.114)	(-2.015)	(-2.165)	(-2.178)
Larger Proportion English-speaking	0.0988***	0.101***	0.0906**	0.0902**
	(2.647)	(2.682)	(2.518)	(2.505)
Poorer than Merging Partners	-0.00587	-0.00640	-0.00392	-0.00372
	(-0.155)	(-0.169)	(-0.107)	(-0.102)
Constant	0.0891	0.0900	0.101*	0.101*
	(1.536)	(1.557)	(1.699)	(1.687)
Neighbourhood Weight Matrix	W	W_{lang}	W	W_{lang}
Controls[a]	Yes	Yes	Yes	Yes
N	194	194	194	194
R^2	0.510	0.511	0.524	0.525

Note: Estimated in MATLAB using the *sar* and *sem* functions of the Spatial Econometrics Toolbox developed by James P. Lesage. Asymptotic t-statistics in parentheses.
Significance levels: *** 1% ** 5% * 10%

[a] Controls include Difference in Public Spending per Capita, Tax Impact (5 years), Distance to core city, Population Density, Share of merger population, Size of Largest Town in Merger (thousands).

independent variables on the probability of a successful secession. However, for a referendum to be successful, two conditions had to be met: enough votes in favour, and a high enough turnout. In this appendix, I will discuss the importance of this participation criterion in the definition of the dependent variable.

For a referendum to be successful, it had not only to gather more than 50 per cent of the expressed votes in favour of re-constitution, but also to gather the votes of at least 35 per cent of the registered voter population in favour of re-constitution. That turnout rule was important in determining the number of secessions. Indeed, while 31 towns were reconstituted in 2004, if the turnout rule had not existed, 58 towns would have been reconstituted.

To examine whether this rule is important for my results, one possibility is to consider another categorical variable, more sophisticated than a binary one. To that effect, I group the towns in 4 categories:

- No referendum: Towns without a referendum
- No criteria met: Towns with a failed referendum
- Participation criterion (PC) not met: Towns with a referendum that had a majority in favour of secession, but without meeting the turnout rule
- Referendum successful: Towns that seceded

Using a multinomial Logit model, it is then possible to examine how the independent variables affect the probability for towns to be in one of these 4 categories.

Table 3.10 shows the marginal effects for each category. Consistently with previous results, language differences increase the probability to be in the two categories indicating the strong presence of secession preferences: actual town re-constitutions, and large vote share for secession with low participation (categories 3 and 4). Considering income differences, richer towns are more likely to be in the third category (large share of votes for de-merger, but not enough participation; column 2), while larger income differences increase the probability of an actual secession (category 4; column 3). These results might suggest that richer cities are more likely to support secession, but only actually de-merge when income differences are high.

Although different, these results are not completely inconsistent with the previous analyses. For language differences, the results are qualitatively the same: larger differences result in more votes in favour of secession as well as more secessions. Regarding income differences, the results from the Multinomial Logit suggest that there is actually an impact from being richer than the agglomeration on the share of votes for secession, in contrast to the previous analysis. In fact, richer towns are more likely to gather a large proportion of votes in favour of secession. However, being richer has no impact on the probability of a successful secession, only the magnitude of income differences does. However, the overall message is the same: income differences do play a role in the voters' decision to favour secession or not.

In the previous analysis including interaction terms, I was comparing category 4 to the three others (successful secession vs. all other outcomes). It may be interesting to estimate the Multinomial Logit model with the interaction term. Table 3.11 reports the results of these estimations. Columns 1 to 3 reports the results using "No Referendum" as the base outcome, while column 4 shows the coefficients using "Participation Criterion Not Met" as the base outcome. I find a positive coefficient on the interaction term only when the base outcome is "Participation Criterion Not Met," indicating that the relationship is especially important when comparing Outcomes 3 to 4 (a referendum failed due to low participation vs. a successful referendum).

Table 3.12 shows the average marginal effects for the main variables. It shows that the average marginal effects are similar with and without interaction terms. However, I am also interested in the marginal effect of income differences at various levels of language differences, as in earlier analyses. Figure 3.4 shows the marginal effects of differences in income on the probability of outcomes 3 and 4. The estimates are imprecise, but the relationship is nevertheless interesting. At higher levels of language differences, income differences decreases the probability of Outcome 3 (referendum failed due to low participation) and increase the probability of Outcome 4 (successful referendum). This result is in line with previous discussions.

3.7 Conclusion

This chapter investigates the determinants of municipal consolidations. The main contribution is to consider the choice of voters for municipal borders, and especially how ethnic diversity affects voters' choices. First, I find that differences in income and linguistic composition between a town and the rest of the merger increases the probability of a secession. To investigate whether these effects are simply a reflection of differing preferences for public goods (correlated with income and language), or due to a preference for cultural homogeneity, I analyse the interaction effects between differences in income and linguistic composition. I find that income differences

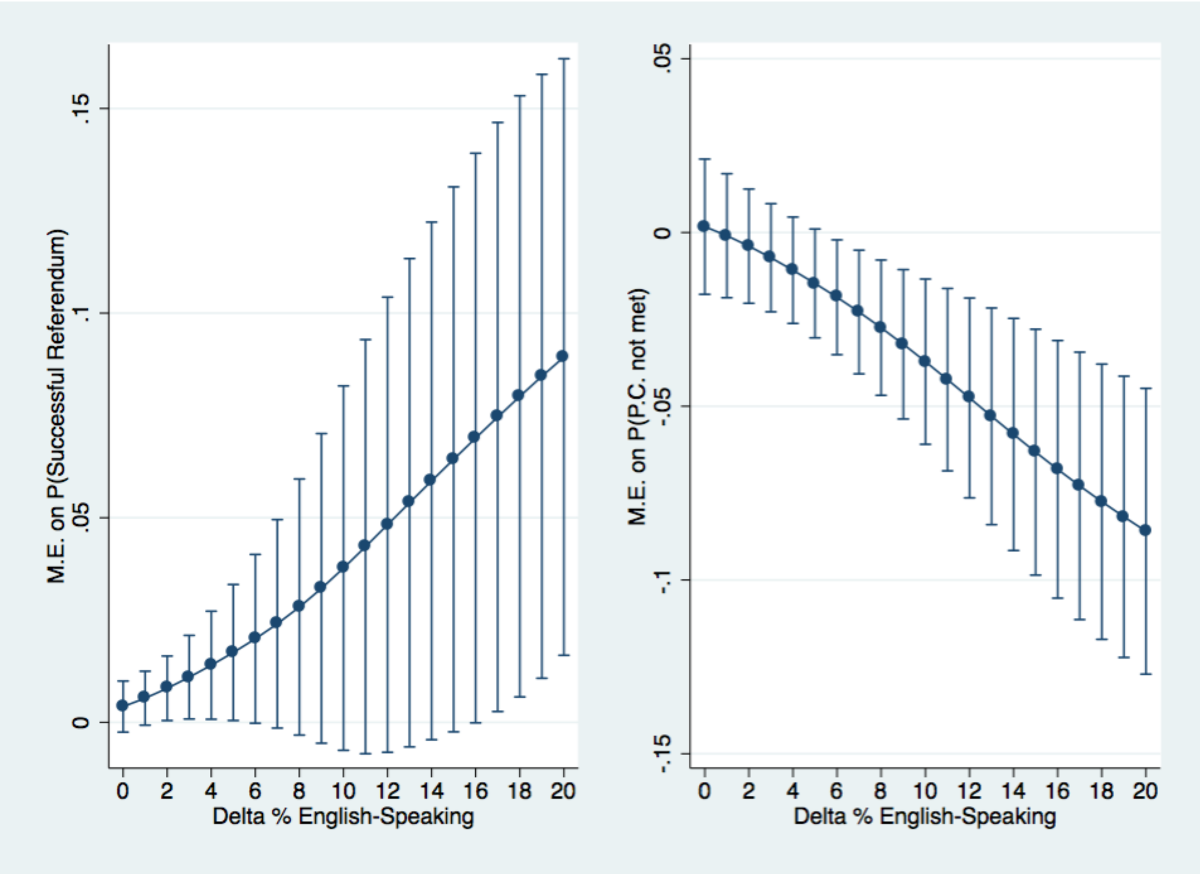


Figure 3.4: Average Marginal Effects of Differences in Median Income on Probability of Selected Outcomes (with 95% Confidence Intervals)

Table 3.10: Multinomial Logit Model, Marginal Effects

	Base Outcome: No referendum		
	(1) No criteria met	(2) PC not met	(3) Referendum passed
Delta Median Income (thousands)	-0.0155	-0.0085	0.0125**
	(0.01)	(0.01)	(0.01)
Delta % English-Speaking	-0.0096	0.0129***	0.0077***
	(0.01)	(0.00)	(0.00)
Larger Proportion English-Speaking	-0.0187	0.0792**	0.0978***
	(0.05)	(0.04)	(0.03)
Poorer than merging partners (in median income)	-0.0145	-0.1175***	-0.0278
	(0.05)	(0.04)	(0.05)
Delta Public Spending per Capita	-0.0176	-0.0107	0.0358
	(0.10)	(0.05)	(0.03)
Tax Impact (5 years)	0.0009	0.0021	-0.0055***
	(0.00)	(0.00)	(0.00)
Distance to core city	0.0027**	-0.0039	-0.0025
	(0.00)	(0.00)	(0.00)
Population Density	0.0001	-0.0001*	-0.0000
	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)
Share of merger population	-0.0020	-0.0052***	-0.0023*
	(0.00)	(0.00)	(0.00)
Size of Largest Town in Merger (thousands)	-0.0005**	0.0002**	0.0001**
	(0.00)	(0.00)	(0.00)

The table reports marginal effects calculated from Multinomial Logit results (estimated with clustered standard errors). Robust standard errors in parentheses. Significance levels: *** 1% ** 5% * 10%

Table 3.11: Multinomial Logit Model, with Interaction Term

	Base Outcome: No referendum			Base Outcome: PC not met
	(1) No criteria met	(2) PC not met	(3) Referendum passed	(4) Referendum passed
Delta Median Income (thousands)	-0.1999	-0.0048	0.0636	0.0684
	(0.13)	(0.13)	(0.09)	(0.10)
Delta % English-Speaking	-0.1337	0.2264***	0.1398	-0.0866
	(0.11)	(0.09)	(0.09)	(0.06)
Delta Median Income (thousands) * Delta % English-Speaking	0.0305	-0.0148	0.0334	0.0482**
	(0.03)	(0.02)	(0.03)	(0.02)
Larger Proportion English-Speaking	0.2084	1.6608***	2.9658***	1.3050
	(0.57)	(0.59)	(1.04)	(0.83)
Poorer than merging partners (in median income)	-0.4700	-1.9685***	-1.0596	0.9089
	(0.47)	(0.59)	(0.91)	(1.02)
Delta Public Spending per Capita	-0.0093	0.0354	1.0558	1.0204**
	(0.92)	(0.86)	(1.07)	(0.42)
Tax Impact (5 years)	0.0014	-0.0091	-0.1047**	-0.0956*
	(0.02)	(0.02)	(0.05)	(0.05)
Distance to core city	0.0118	-0.0557	-0.0892**	-0.0335
	(0.01)	(0.04)	(0.04)	(0.05)
Population Density	0.0004	-0.0008*	-0.0008*	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Population in 2001	0.0000	0.0000**	0.0000	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Share of merger population	-0.0360**	-0.0863***	-0.1071***	-0.0208
	(0.02)	(0.02)	(0.03)	(0.03)
Size of Largest Town in Merger (thousands)	-0.0038	0.0029**	0.0022	-0.0007
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-0.1111	-0.1917	-2.0305	-1.8388**
	(0.53)	(1.24)	(1.30)	(0.93)
N	194			
Pseudo-R^2	0.376			
$\chi^2 test(p\text{-}value)$	n.a.[a]			

[a] The χ^2 test with fixed effects and clustered standard errors cannot be estimated (not enough information).
The table reports Multinomial Logit coefficients. Clustered standard errors in parentheses. Significance levels: *** 1% ** 5% * 10%

Table 3.12: Multinomial Logit Model with Interactions, Marginal Effects

	Base Outcome: No referendum		
	(1) No criteria met	(2) PC not met	(3) Referendum passed
Delta Median Income (thousands)	-0.0172*	-0.0150	0.0197**
	(0.01)	(0.01)	(0.01)
Delta % English-Speaking	-0.0098	0.0110**	0.0091**
	(0.01)	(0.01)	(0.00)
Larger Proportion English-Speaking	-0.0213	0.0796**	0.1006***
	(0.05)	(0.04)	(0.04)
Poorer than neighbors (in median income)	-0.0138	-0.1398***	-0.0061
	(0.05)	(0.04)	(0.04)
Delta Public Spending per Capita	-0.0079	-0.0179	0.0474*
	(0.10)	(0.06)	(0.03)
Tax Impact (5 years)	0.0009	0.0013	-0.0046***
	(0.00)	(0.00)	(0.00)
Distance to core city	0.0027**	-0.0032	-0.0030*
	(0.00)	(0.00)	(0.00)
Population Density	0.0001	-0.0001**	-0.0000
	(0.00)	(0.00)	(0.00)
Population in 2001	0.0000	0.0000*	0.0000
	(0.00)	(0.00)	(0.00)
Share of merger population	-0.0019	-0.0047***	-0.0029**
	(0.00)	(0.00)	(0.00)
Size of Largest Town in Merger (thousands)	-0.0005*	0.0003**	0.0001
	(0.00)	(0.00)	(0.00)

The table reports marginal effects calculated from Multinomial Logit results (estimated with clustered standard errors). Robust standard errors in parentheses. Significance levels: *** 1% ** 5% * 10%

matter more in towns where language differences are large. I interpret this result as a group loyalty effect. Voters' choices are more affected by income differences when they must share a jurisdiction with people of a different linguistic group. This result is robust to the addition of additional variables such as differences in house values and turnout at the referendum, and to the choice of specification, including to the inclusion of a spatial lag.

In addition to the more academic interest in the determinants of jurisdiction borders, this chapter can also provide some more concrete lessons for policy-makers. When promoting municipal mergers, governments often tout the economies of scale realized compared to a more fractionated map. However, voters seem to care more about the heterogeneity of people in the jurisdiction. Given the difficulties encountered by some governments in promoting these mergers (notably, in Quebec), my results may help create borders that are more likely to be accepted. However, if governments care about the potential long-term benefits of ethnic diversity in local jurisdictions (as suggested by Putnam (2007) and Ottaviano and Peri (2005)), my results suggest that they may prefer to impose mergers, and commit to a policy of not allowing de-mergers.

Appendix

3.A Determinants of Municipal Public Spending Per Capita

Table 3.A.1: Determinants of Public Spending

	(1)	(2)	(3)	(4)
% English-Speaking	2.8383*	-5.0526	3.9537	9.7735
	(1.70)	(6.48)	(3.77)	(11.82)
Median Income	0.0129*	0.0099	-0.0361**	-0.0337**
	(0.01)	(0.01)	(0.02)	(0.02)
Interaction		0.0004		-0.0002
		(0.00)		(0.00)
Average House Values	-0.0001	-0.0005	0.0042***	0.0045***
	(0.00)	(0.00)	(0.00)	(0.00)
Ratio of Average over Median Income	332.8919***	322.2829**	-79.2582	-58.0270
	(122.64)	(125.51)	(312.00)	(314.62)
% Immigrants	-1.1765	-2.9466	-26.6102*	-27.9376*
	(5.98)	(6.30)	(14.05)	(15.92)
% Visible Minorities	-18.2086	-15.1918	1.9164	1.9951
	(14.39)	(15.88)	(15.68)	(15.77)
% University Educated	5.3914*	4.7227	12.1055*	11.9941*
	(3.22)	(3.05)	(6.51)	(6.62)
Unemployment Rate	8.4321***	7.9712***	-0.1696	0.5739
	(2.07)	(1.81)	(6.94)	(6.11)
% Immigrants from Other Municipalities	1.9864	2.4545	-0.3255	-0.9409
	(1.81)	(1.73)	(4.20)	(4.40)
Density	-0.0486	-0.0419	-0.1164**	-0.1180**
	(0.04)	(0.04)	(0.05)	(0.06)
Population	0.0011*	0.0012**	0.0010*	0.0010*
	(0.00)	(0.00)	(0.00)	(0.00)
Montreal	1115.3045**	1011.0588*	1127.6670	1151.1621
	(521.85)	(574.90)	(736.52)	(780.88)
Constant	-39.8320	55.3014	1274.7261*	1175.0382*
	(223.56)	(253.69)	(667.21)	(627.98)
N	1233	1233	204	204
R^2	0.224	0.230	0.429	0.429

Note: Robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%
Columns 3 and 4 only include municipalities part of the merger wave.

3.B Appendix Tables

Table 3.B.1: Determinants of De-Mergers: Additional Results

	(1) OLS	(2) OLS	(5) OLS	(6) OLS	(3) Probit M.E.	(4) Probit M.E.	(7) Probit M.E.	(8) Probit M.E.
Diff. Median Income (thousands)	0.0176**	0.0127	0.0226***	0.0118*	0.0120***	0.0102*	0.0082***	0.0113**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
Diff. English-Speaking Proportion	0.0067**	0.0107***	0.0106**	0.0113***	-0.0002	0.0038**	0.0111***	0.0042***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Larger Proportion English-speaking	0.1105***	0.0960***	0.0789**	0.0982***	0.1111***	0.0919***	0.0673	0.1006***
	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.07)	(0.03)
Poorer than merging partners	-0.0279	0.0041	-0.0185	-0.0383	-0.0543	-0.0116	-0.0961	-0.0363
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.07)	(0.04)
Diff. % of Votes for Bloc Québécois	0.0138**				0.0087***			
	(0.01)				(0.00)			
Diff. House Values		0.0010**				0.0006**		
		(0.00)				(0.00)		
Diff. Public Spending per Capita	0.0425	0.0571	0.1300***	0.0376	0.0297*	0.0412*	0.1400	0.0331**
	(0.05)	(0.05)	(0.03)	(0.06)	(0.02)	(0.02)	(0.14)	(0.02)
Tax Impact (5 years)	-0.0049***	-0.0043**	-0.0043**	-0.0044**	-0.0047***	-0.0043***	-0.0108***	-0.0048***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Distance to core city	-0.0018*	-0.0009	-0.0026**	-0.0011	-0.0013	-0.0020	-0.0007	-0.0016
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Density	-0.0000***	-0.0000***	-0.0001***	-0.0000**	-0.0000	-0.0000**	-0.0001***	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Population	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000**	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0028**	-0.0030**	-0.0034**	-0.0025**	-0.0033***	-0.0034***	-0.0140**	-0.0033**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Size of Largest Town in Merger (thousands)	0.0001	0.0002**	-0.0198	-0.0000	0.0000	0.0001	0.0114	-0.0000
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)
Diff. Median Age				0.0077				0.0083
				(0.01)				(0.01)
Diff. Unemployment Rate				0.0042				0.0018
				(0.01)				(0.00)
Diff. % of Visible Minorities				0.0265				0.0098**
				(0.02)				(0.00)
Diff. % University-Educated				0.0037				-0.0003
				(0.01)				(0.00)
Diff. Recent Intra-Provincial Migrants				-0.0018				-0.0054
				(0.00)				(0.00)
Diff. Inequality (Average over Median Income)				-0.2641				-0.3303**
				(0.21)				(0.15)
Constant	0.0167	0.0605	0.1768*	0.0332	n.a.	n.a.	n.a.	n.a.
	(0.05)	(0.05)	(0.10)	(0.05)				
Merger Fixed Effects	No	No	Yes	No	No	No	Yes	No
N	194	194	194	194	194	194	72	194
R^2	0.531	0.506	0.623	0.541	0.637	0.586	0.741	0.647
F-test (*p-value*)	0.000	0.000	n.a.[a]	0.000	0.000	0.000	n.a.[b]	0.000

Note: For OLS, clustered (by merger) robust standard errors in parentheses. For Probit, marginal effects are reported, with robust standard errors (unconditional) in parentheses. Probit estimations themselves calculated using clustered standard errors (by merger).
Significance levels: *** 1% ** 5% * 10%

[a] The F-test with fixed effects and clustered standard errors cannot be estimated (not enough information).

[b] The χ^2 test with fixed effects and clustered standard errors cannot be estimated (not enough information).

Table 3.B.2: Interactions between Continuous Income and Language Variables: With Merger Fixed Effects

	(4) OLS	(3) Probit
Diff. Median Income (thousands)	0.0042	-0.0389
	(0.02)	(0.06)
Diff. English-Speaking Proportion	-0.0032	0.0283
	(0.01)	(0.07)
Diff. Median Income * Diff. English-Speaking Proportion	0.0044***	0.0349**
	(0.00)	(0.01)
(Diff. Median Income)^2	0.0005	
	(0.00)	
(Diff. Median Income)^2 * Diff. English-Speaking Proportion	-0.0002***	
	(0.00)	
Larger Proportion English-speaking	0.0799**	0.3840
	(0.04)	(0.52)
Poorer than merging partners	-0.0133	-0.4670
	(0.03)	(0.56)
Diff. Public Spending per Capita	0.1619***	1.3062
	(0.03)	(1.73)
Tax Impact (5 years)	-0.0043**	-0.1227***
	(0.00)	(0.03)
Distance to core city	-0.0028**	0.0030
	(0.00)	(0.02)
Density	-0.0001**	-0.0007***
	(0.00)	(0.00)
Population	-0.0000	0.0000
	(0.00)	(0.00)
Share of Merger Population	-0.0037**	-0.1293***
	(0.00)	(0.04)
Size of Largest Town in Merger (thousands)	-0.0283*	0.2924
	(0.02)	(0.22)
Constant	0.2624**	-1.3089
	(0.11)	(1.38)
Merger Fixed Effects	Yes	Yes
N	194	72
R^2	0.628	0.773

Note: Clustered (by merger) robust standard errors in parentheses. For Probit: reporting Probit coefficients.
Significance levels: *** 1% ** 5% * 10%
The F and χ^2 tests with fixed effects and clustered standard errors cannot be estimated (not enough information).

Table 3.B.3: Interactions between Continuous Income and Language Variables: OLS Results (Robustness Check: House Values and Political Preferences)

	(1)	(2)	(3)	(4)	(5)	(6)
Diff. Median Income (thousands)	0.0116	0.0027	0.0129	-0.0019	0.0115	0.0005
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Diff. English-Speaking Proportion	0.0099*	-0.0033	0.0047	-0.0052	0.0056	-0.0079
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Diff. Median Income * Diff. English-Speaking Proportion	0.0002	0.0050***	0.0004	0.0040**	0.0001	0.0051***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Diff. House Values	0.0008*	0.0019***			0.0007	0.0017**
	(0.00)	(0.00)			(0.00)	(0.00)
Diff. % of Votes for Bloc Québécois			0.0135*	0.0139**	0.0132*	0.0133**
			(0.01)	(0.01)	(0.01)	(0.01)
(Diff. Median Income)^2		-0.0001		0.0010		0.0001
		(0.00)		(0.00)		(0.00)
(Diff. Median Income)^2 * Diff. English-Speaking Proportion		-0.0003***		-0.0002**		-0.0003***
		(0.00)		(0.00)		(0.00)
Larger Proportion English-speaking	0.0963***	0.0932**	0.1106***	0.1093**	0.1096***	0.1066**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Poorer than merging partners	0.0025	0.0249	-0.0270	-0.0217	-0.0171	0.0054
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Diff. Public Spending per Capita	0.0579	0.1082*	0.0465	0.0765	0.0486	0.0994*
	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
Tax Impact (5 years)	-0.0044**	-0.0040**	-0.0048***	-0.0048***	-0.0046***	-0.0042**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Distance to core city	-0.0009	-0.0007	-0.0018*	-0.0020**	-0.0014	-0.0012
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Density	-0.0000***	-0.0000**	-0.0000***	-0.0000**	-0.0000***	-0.0000***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Population	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0030**	-0.0032***	-0.0028**	-0.0029**	-0.0029**	-0.0031**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Size of Largest Town in Merger (thousands)	0.0002***	0.0001	0.0001	0.0000	0.0001	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	0.0658	0.0740	0.0330	0.0567	0.0303	0.0414
	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)
N	194	194	194	194	194	194
R^2	0.506	0.532	0.534	0.548	0.537	0.564
F-test (*p-value*)	0.000	0.000	0.000	0.000	0.000	0.000

Note: Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.4: Interactions between Continuous Income and Language Variables: Probit Results (Robustness Check: House Values and Political Preferences)

	(1)	(2)	(3)	(4)	
Diff. Median Income (thousands)	0.0314	0.0644	0.0159	0.0553	-0.0395
	(0.05)	(0.04)	(0.05)	(0.13)	(0.10)
Diff. English-Speaking Proportion	-0.0189	-0.1080**	-0.1348**	-0.1003	-0.0089
	(0.04)	(0.05)	(0.05)	(0.07)	(0.02)
Diff. Median Income * Diff. English-Speaking Proportion	0.0227*	0.0297***	0.0337***	0.0344***	
	(0.01)	(0.01)	(0.01)	(0.01)	
Diff. House Values	0.0061*		0.0123**	0.0116**	0.0131**
	(0.00)		(0.01)	(0.00)	(0.01)
Diff. % of Votes for Bloc Québécois		0.1364***	0.1559***	0.1449***	0.0188
		(0.05)	(0.05)	(0.05)	(0.05)
Diff. Median Income * Diff. % of Votes for Bloc Québécois					0.0323**
					(0.02)
(Diff. English-Speaking Proportion)^2				-0.0005	
				(0.00)	
(Diff. Median Income)^2				-0.0039	
				(0.01)	
Larger Proportion English-speaking	1.0615***	1.6279***	1.6144***	1.4963***	1.6522***
	(0.37)	(0.43)	(0.45)	(0.36)	(0.39)
Poorer than merging partners	-0.0132	-0.5002	-0.3678	-0.3303	-0.5224
	(0.42)	(0.52)	(0.50)	(0.50)	(0.53)
Diff. Public Spending per Capita	0.6535**	0.5864**	0.8138***	0.8334***	0.9566***
	(0.28)	(0.25)	(0.28)	(0.27)	(0.36)
Tax Impact (5 years)	-0.0452**	-0.0581***	-0.0529***	-0.0525***	-0.0616***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Distance to core city	-0.0262	-0.0310	-0.0146***	-0.0126***	-0.0116
	(0.02)	(0.03)	(0.01)	(0.00)	(0.01)
Density	-0.0002***	-0.0002*	-0.0003***	-0.0003***	-0.0002**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000**	0.0000**	0.0000*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0418***	-0.0504***	-0.0455***	-0.0452***	-0.0454***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Size of Largest Town in Merger (thousands)	0.0002	-0.0003	-0.0004	-0.0007	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-1.6021***	-2.3080***	-2.6108***	-2.6601***	-2.4635***
	(0.47)	(0.57)	(0.53)	(0.53)	(0.47)
N	194	194	194	194	194
Pseudo-R^2	0.610	0.674	0.687	0.691	0.682
χ^2-test (*p-value*)	0.000	0.000	0.000	0.000	0.000

Note: Table reports Probit coefficients. Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.5: Interactions between Continuous Income and Language Variables: OLS Results (Robustness Check: Median Income)

	(1)	(2)	(3)
Diff. Median Income (thousands)	0.0163***	0.0008	0.0007
	(0.01)	(0.02)	(0.01)
Diff. English-Speaking Proportion	0.0114***	-0.0001	-0.0077
	(0.00)	(0.01)	(0.01)
Diff. Median Income * Diff. English-Speaking Proportion		0.0038***	0.0050***
		(0.00)	(0.00)
Larger Proportion English-speaking	0.0958***	0.0951**	0.1068**
	(0.03)	(0.04)	(0.04)
Median Income	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)
Diff. House Values			0.0017***
			(0.00)
Diff. % of Votes for Bloc Québécois			0.0135**
			(0.01)
(Diff. Median Income)^2		0.0006	0.0000
		(0.00)	(0.00)
(Diff. Median Income)^2 * Diff. English-Speaking Proportion		-0.0002**	-0.0003***
		(0.00)	(0.00)
Diff. Public Spending per Capita	0.0549	0.0878	0.1005*
	(0.06)	(0.06)	(0.05)
Tax Impact (5 years)	-0.0046**	-0.0045**	-0.0042**
	(0.00)	(0.00)	(0.00)
Distance to core city	-0.0013	-0.0014	-0.0012
	(0.00)	(0.00)	(0.00)
Density	-0.0000***	-0.0000*	-0.0000***
	(0.00)	(0.00)	(0.00)
Population	-0.0000	-0.0000	-0.0000
	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0029**	-0.0030***	-0.0030***
	(0.00)	(0.00)	(0.00)
Size of Largest Town in Merger (thousands)	0.0002*	0.0001	0.0000
	(0.00)	(0.00)	(0.00)
Constant	-1.9999	-1.5472	-3.3096**
	(1.40)	(1.38)	(1.34)
N	194	194	194
R^2	0.498	0.515	0.565
F-test (*p-value*)	0.000	0.000	0.000

Note: Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.6: Interactions between Continuous Income and Language Variables: Probit Results (Robustness Check: Median Income)

	(1)	(2)	(3)	(4)
Diff. Median Income (thousands)	0.1427*	0.0584	-0.0098	0.0779
	(0.08)	(0.07)	(0.08)	(0.11)
Diff. English-Speaking Proportion	0.0445**	-0.0177	-0.1354**	-0.1014
	(0.02)	(0.04)	(0.05)	(0.07)
Diff. Median Income * Diff. English-Speaking Proportion		0.0232**	0.0344***	0.0345**
		(0.01)	(0.01)	(0.01)
Larger Proportion English-speaking	1.0678***	1.1057***	1.5906***	1.4532***
	(0.37)	(0.41)	(0.48)	(0.38)
Median Income	0.0000	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Diff. House Values			0.0127**	0.0120**
			(0.01)	(0.01)
Diff. % of Votes for Bloc Québécois			0.1524***	0.1412***
			(0.04)	(0.04)
(Diff. Median Income)^2				-0.0084
				(0.01)
(Diff. English-Speaking Proportion)^2				-0.0005
				(0.00)
Diff. Public Spending per Capita	0.3458	0.5586**	0.7859***	0.8125***
	(0.25)	(0.25)	(0.26)	(0.26)
Tax Impact (5 years)	-0.0518**	-0.0490**	-0.0516***	-0.0516***
	(0.02)	(0.02)	(0.02)	(0.02)
Distance to core city	-0.0344	-0.0375	-0.0144**	-0.0126**
	(0.02)	(0.02)	(0.01)	(0.01)
Density	-0.0002**	-0.0002**	-0.0003***	-0.0003***
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0418***	-0.0460***	-0.0460***	-0.0456***
	(0.01)	(0.01)	(0.01)	(0.01)
Size of Largest Town in Merger (thousands)	0.0007*	0.0002	-0.0004	-0.0006
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-1.9999	-1.5472	-3.3096**	-3.3955**
	(1.40)	(1.38)	(1.34)	(1.46)
N	194	194	194	194
Pseudo-R^2	0.580	0.606	0.686	0.691
χ^2-test (*p-value*)	0.000	0.000	0.000	0.000

Note: Table reports Probit coefficients. Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.7: Interactions between Continuous Income and Language Variables: OLS Results (Robustness Check: Turnout)

	(1)	(2)	(3)	(4)
Diff. Median Income (thousands)	0.0234	0.1040**	0.0881*	0.0634
	(0.02)	(0.04)	(0.04)	(0.04)
Diff. English-Speaking Proportion	0.0077	-0.0003	0.0097	-0.0088
	(0.01)	(0.00)	(0.01)	(0.01)
Diff. Median Income * Diff. English-Speaking Proportion	-0.0001	0.0016	0.0024*	0.0044**
	(0.00)	(0.00)	(0.00)	(0.00)
Larger Proportion English-speaking	0.1560*	0.1649**	0.1521*	0.1840**
	(0.08)	(0.08)	(0.08)	(0.08)
Poorer than Merging Partners	0.0117	0.0544	0.0457	-0.0048
	(0.09)	(0.09)	(0.09)	(0.09)
Turnout	0.0124***	0.0130***	0.0132***	0.0124***
	(0.00)	(0.00)	(0.00)	(0.00)
Diff. House Values				0.0008
				(0.00)
Diff. % of Votes for Bloc Québécois				0.0214**
				(0.01)
(Diff. Median Income)^2		-0.0076**	-0.0063*	-0.0050
		(0.00)	(0.00)	(0.00)
(Diff. Median Income)^2 * Diff. English-Speaking Proportion		-0.0000	-0.0001	-0.0002*
		(0.00)	(0.00)	(0.00)
(Diff. English-Speaking Proportion)^2			-0.0002**	-0.0001
			(0.00)	(0.00)
Diff. Public Spending per Capita	0.1105***	0.1777***	0.1858***	0.1923***
	(0.03)	(0.03)	(0.03)	(0.04)
Tax Impact (5 years)	-0.0084***	-0.0089***	-0.0086***	-0.0081***
	(0.00)	(0.00)	(0.00)	(0.00)
Distance to core city	-0.0016	-0.0016	-0.0013	-0.0023
	(0.00)	(0.00)	(0.00)	(0.00)
Density	-0.0000	0.0000	0.0000	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0042	-0.0049	-0.0057	-0.0060
	(0.00)	(0.00)	(0.00)	(0.00)
Size of Largest Town in Merger (thousands)	0.0001	-0.0000	-0.0001	-0.0003*
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-0.5848**	-0.7621***	-0.7582***	-0.7167**
	(0.28)	(0.25)	(0.26)	(0.30)
N	81	81	81	81
R^2	0.551	0.588	0.602	0.646
F-test (*p-value*)	0.000	0.000	0.000	0.000

Note: Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.8: Interactions between Continuous Income and Language Variables: Probit Results (Robustness Check: Turnout)

	(1)	(2)	(3)
Diff. Median Income (thousands)	0.0452	0.5581**	0.5221**
	(0.05)	(0.28)	(0.23)
Diff. English-Speaking Proportion	-0.0161	0.0698**	-0.0080
	(0.04)	(0.03)	(0.06)
Diff. Median Income * Diff. English-Speaking Proportion	0.0282**	0.0163**	0.0202**
	(0.01)	(0.01)	(0.01)
Larger Proportion English-speaking	0.8191	0.8523	1.5530*
	(0.61)	(0.69)	(0.84)
Poorer than Merging Partners	0.5679	0.8325	0.3281
	(0.57)	(0.66)	(0.81)
Turnout	0.0842***	0.0892***	0.1287***
	(0.03)	(0.03)	(0.04)
Diff. House Values			-0.0059
			(0.01)
Diff. % of Votes for Bloc Québécois			0.1670***
			(0.06)
(Diff. Median Income)^2		-0.0380**	-0.0313**
		(0.02)	(0.02)
(Diff. English-Speaking Proportion)^2		-0.0015***	-0.0012
		(0.00)	(0.00)
Diff. Public Spending per Capita	0.8268***	1.0189***	1.0458**
	(0.25)	(0.24)	(0.53)
Tax Impact (5 years)	-0.0456**	-0.0561*	-0.0669***
	(0.02)	(0.03)	(0.02)
Distance to core city	-0.0030	-0.0040	-0.0176**
	(0.00)	(0.00)	(0.01)
Density	0.0001	0.0001	0.0001
	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000*
	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0401	-0.0373	-0.0485
	(0.03)	(0.03)	(0.04)
Size of Largest Town in Merger (thousands)	-0.0004	-0.0004	-0.0014*
	(0.00)	(0.00)	(0.00)
Constant	-6.6977***	-8.2723***	-11.5480***
	(2.10)	(2.22)	(2.30)
N	81	81	81
Pseudo-R^2	0.630	0.664	0.743
χ^2-test (*p-value*)	0.000	0.000	0.000

Note: Table reports Probit coefficients. Clustered (by merger) robust standard errors in parentheses. Significance levels: *** 1% ** 5% * 10%

Table 3.B.9: Interactions between Income and Language Variables (Using Thresholds): Probit Results (Robustness Check: Turnout)

	(1)	(2)	(3)	(4)
Income				
Diff. Median Income (thousands)	0.5407**	0.1529**		
	(0.23)	(0.07)		
Small Income Differences (mean)			-0.7108	
			(0.53)	
Small Income Differences (median)				-0.6571
				(0.55)
Language				
Diff. English-Speaking Proportion			0.0647**	0.0694***
			(0.03)	(0.03)
Small Language Differences (mean)	-1.0702			
	(0.72)			
Small Language Differences (median)		-1.2713		
		(0.85)		
Interaction Language x Income				
Relevant Interaction term	-0.4619**	-0.0544	-0.0118	-0.0216
	(0.21)	(0.08)	(0.03)	(0.03)
Larger Proportion English-speaking	0.7881	0.9959*	0.8790	0.8511
	(0.70)	(0.56)	(0.54)	(0.54)
Poorer than Merging Partners	0.1552	0.5102	0.3834	0.4057
	(0.60)	(0.44)	(0.54)	(0.56)
Turnout	0.1031***	0.0800***	0.0922***	0.0904***
	(0.04)	(0.03)	(0.03)	(0.03)
Diff. Public Spending per Capita	0.7935***	0.5056***	0.6454***	0.5905***
	(0.25)	(0.14)	(0.18)	(0.18)
Tax Impact (5 years)	-0.0723**	-0.0351*	-0.0501**	-0.0493**
	(0.03)	(0.02)	(0.02)	(0.02)
Distance to core city	-0.0029	-0.0110	-0.0016	-0.0073
	(0.00)	(0.01)	(0.00)	(0.00)
Density	0.0001	-0.0001	0.0001	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.0000	0.0000	0.0000	0.0000
	(0.00)	(0.00)	(0.00)	(0.00)
Share of Merger Population	-0.0590*	-0.0626	-0.0379	-0.0414
	(0.03)	(0.04)	(0.03)	(0.03)
Size of Largest Town in Merger (thousands)	-0.0006	0.0004	0.0002	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-6.7096***	-5.6041***	-6.4841***	-6.2655***
	(2.36)	(1.73)	(2.27)	(2.18)
N	81	81	81	81
Pseudo-R^2	0.699	0.613	0.588	0.591
χ^2-test (*p-value*)	0.000	0.000	0.000	0.000

Note: Table reports Probit coefficients. Clustered (by merger) robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.10: Interactions between Income and Language Variables (Using Thresholds): Probit Marginal Effects (Robustness Check: Turnout)

	(1)	(2)
	M.E. of Income	M.E. of Language
Large Language Differences (mean)	0.0663**	
	(0.03)	
Small Language Differences (mean)	0.0076	
	(0.00)	
p-value, t-test	0.042**	
Large Language Differences (median)	0.0270**	
	(0.01)	
Small Language Differences (median)	0.0082**	
	(0.00)	
p-value, t-test	0.079*	
Large Income Differences (mean)		0.0094***
		(0.00)
Small Income Differences (mean)		0.0078**
		(0.00)
p-value, t-test		0.727
Large Income Differences (median)		0.0097***
		(0.00)
Small Income Differences (median)		0.0072**
		(0.00)
p-value, t-test		0.547

Note: Calculated from the Probit coefficients with clustered standard errors. Robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Table 3.B.11: Probit Estimations Including the Weighted Average of the Percentage of Register Signatures in Neighbouring Towns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Avg. % Register Signatures	0.0829**	0.0916*	0.0805**	0.0948*				
(Language-weighted)	(0.04)	(0.05)	(0.04)	(0.05)				
Avg. % Register Signatures					0.0556*	0.0785	0.0542*	0.0848*
(Population-weighted)					(0.03)	(0.05)	(0.03)	(0.05)
Diff. Median Income (thousands)	0.1585***	0.1569**	0.0716	0.0652	0.1714***	0.1621**	0.0838	0.0664
	(0.06)	(0.07)	(0.08)	(0.11)	(0.06)	(0.07)	(0.08)	(0.11)
Diff. % English-Speakers	0.0306**	0.0410**	-0.0320	-0.0353	0.0354**	0.0434**	-0.0282	-0.0344
	(0.02)	(0.02)	(0.04)	(0.05)	(0.02)	(0.02)	(0.03)	(0.05)
Interaction Term			0.0210**	0.0250*			0.0218**	0.0253*
			(0.01)	(0.01)			(0.01)	(0.01)
More English-Speaking	0.3545	0.8040	0.3191	0.8508	0.2593	0.7675	0.2161	0.8250
	(0.43)	(0.73)	(0.45)	(0.75)	(0.43)	(0.71)	(0.44)	(0.74)
Poorer than Merging Partners	0.3680	-0.7518	0.6316	-0.1972	0.3981	-0.7496	0.6730	-0.1977
	(0.50)	(0.62)	(0.46)	(0.50)	(0.48)	(0.61)	(0.46)	(0.50)
Constant	-3.4193***	-3.1909**	-3.1618***	-2.7142**	-2.9402***	-3.0533**	-2.7098***	-2.5934**
	(0.80)	(1.28)	(0.78)	(1.10)	(0.70)	(1.31)	(0.71)	(1.12)
N	72	70	72	70	73	70	73	70
Pseudo-R^2	0.410	0.622	0.456	0.649	0.392	0.615	0.440	0.644
χ^2	34.9	45.7	24.4	44.0	31.6	44.9	22.7	44.3
Controls	No	Yes	No	Yes	No	Yes	No	Yes

Note: Robust standard errors in parentheses.
Significance levels: *** 1% ** 5% * 10%

Chapter 4

An Experimental Study of Secession Under Alternative Levels of Decentralisation[1]

[1]A preliminary version of this chapter appeared in Bjedov (2015). This chapter was prepared in collaboration with Tjasa Bjedov, Thierry Madiès, and Marie-Claire Villeval. This research was supported by a grant from the University of Fribourg and was performed within the framework of the LABEX CORTEX (ANR-11-LABX-0042) of the University of Lyon, within the program "Investissements d'Avenir" (ANR-11-IDEX-007). The authors are grateful to Quentin Thévenent for the programmation of the experiment. This chapter benefited from discussions with researchers at the IQSS (Harvard University), and was presented at the Universities of Fribourg and Lyon, and at the Journées de Microéconomie Appliquée, in Besançon (France).

4.1 Introduction

In recent decades, we observe two parallel trends. First, many new independent states have emerged, either through secession, decolonisation or through the dismantling of existing countries. Recently, for example, South Sudan gained its independence from Sudan, and central governments in Belgium (Flanders), the United Kingdom (Scotland), and Spain (Catalonia) have been dealing with secessionist movements in some regions of their countries. Simultaneously to these separatist trends, both OECD and developing countries have experienced an increase in fiscal and political decentralization. Nowadays, for example, the OECD counts about 140 000 sub-national governments, made more powerful and influential by the decentralization trend of the last twenty years (OECD, 2014).

These two parallel trends raise the question whether decentralization can suppress secessionist groups. For example, when central governments are confronted with a secessionist threat in one or more regions they might decide to devolve some power or competences to the regional entity, in the hope that the decentralization of power will accommodate regional demands and thereby quell the separatist movement (Sorens 2004; Lustick, Miodownik, and Eidelson, 2004; Miodownik and Cartrite, 2009). However, granting a region greater autonomy may have two opposing effects. On the one hand, greater autonomy brings the overall mix of public goods closer to the local preferences, and more generally increases the confidence of citizens that their interests are well or even better represented. On the other hand, as argued by Lustick, Miodownik and Eidelson (2004: 210): "creating autonomous, federal, or otherwise devolved institutions of self-government or self-administration [...] is liable to contribute to secessionism by affording elites and groups the political resources they need to undertake mass mobilization and wage separatist struggles." Consequently, devolving the power of self-administration to other layers of government is a double-edged sword. As such, it is not clear whether decentralization actually decreases the probability of a country to break up. Ezgi (2009) makes a similar argument, reasoning that the effect of decentralisation on secession movements depend on the nature of the regions' grievances. If they are material, such that the conflict arises from, e.g., the composition of public goods, then decentralisation will reduce secession incentives. However, if grievances are symbolic (e.g., they result from ethnic differences), then decentralisation does nothing to reduce secession incentives, and instead just provides regions with self-governing experience, essentially reducing the costs of secession. The objective of this chapter is to find whether decentralisation increases or decreases the probability votes for regional secession, using a laboratory experiment.

This question is more than theoretical. For example, following the rise in popularity of the Scottish nationalist movement in the 1960s and 1970s, the central government in the United Kingdom started entertaining the idea of making concessions to that region. In 1973, the Royal Commission on the Constitution submitted a report, proposing the creation of regional parliaments (including in Scotland), a proposal that materialised with the Scotland Act of 1998. Nevertheless, Scotland organised, in 2014, a referendum on secession. Without observing the counter-factual, it is virtually impossible to know whether the increased decentralization helped keep the Union together, or if it actually contributed to the growth of the secessionist movement. Another example is Canada, where following the failed referendums in the province of Quebec, central governments have devolved the administration (at least in part) of a number of programs, such as the public pension system, to provinces that asked for it (mostly Quebec).

The economic analysis of secession is mostly theoretical, including the seminal contributions of Alesina and Spolaore (1997) and Bolton and Roland (1997). These papers highlight the importance of the basic trade-off at play between a better matching between the public goods and the preference of voters in smaller jurisdictions and the economies of scale to be gained in larger jurisdictions. The rarity (and idiosyncrasies) of actual secessions make it difficult to analyse real-world secessionist movements empirically (Spolaore, 2008). Some authors who attempted such analyses include Bakke and Wibbels (2006), Sorens (2004), Brancati (2006), and Ezgi (2009). This chapter instead turns to a laboratory experiment to study the decision of "sub-national" groups to secede. Specifically, we examine the effects on secession votes of (1) different levels of decentralization in the supply of public goods and of (2) the salience of local group identities on the decision to secede. While the laboratory imposes restrictions on the complexity of the institutions that can be modelled, it has the advantage of creating a large dataset of comparable instances of secession votes, with no endogeneity problem inherent to most empirical studies. The other advantage is the possibility to modify institutions to study how it affects the decision to vote for a secession, keeping everything else constant.

To this purpose, we build an original experimental design based on a multiple public good game using the voluntary contribution mechanism (VCM) (Isaac and Walker, 1988). When arriving at the laboratory, subjects are randomly put into groups. The large groups, which we name global groups, are composed of 9 subjects. These 9 subjects are then divided in 3 local groups of 3 subjects. Consequently, each subject is a member of two groups, and interacts with others in these two groups. The public goods game has multiple public goods supplied at two different levels: at the local level and at the global level. All 9 subjects in a global group contribute to the global public goods, while subjects can only contribute to the local public goods corresponding to their own local group. Since there are more individuals in the global group, the global public good has a higher potential social return. Additionally, the marginal per capita returns (MPCR) of these two types of public goods are different. Namely, the MPCR is 0.5 for the local public goods and 0.2 for the global public goods.

The timing of the experiment is as follows. In the first part, subjects decide the share of their endowment to contribute to each group account while keeping the remainder on their private account. After 12 periods under this configuration, the second part takes place, in which subjects repeat the exercise, but with three local public goods for the same number of periods. This configuration allows the subjects to experience a "seceded" configuration (basically full decentralisation).[2] At the beginning of the third part of the experiment, individuals are asked to vote over these two institutional arrangements, knowing that they will play the next 12 periods in the configuration that obtained the majority of votes. A vote for three local public goods is therefore essentially a vote for a local secession.

Our experiment uses a 2×2 design, where the two dimensions of treatment are the level of decentralisation and the salience of the local group identity. The first dimension, the level of decentralisation, modifies the configuration of the public goods available to the subjects. In the Centralisation treatments, subjects face two global public goods and one local public good. In the Decentralization treatments, the first part of the experiment is modified. Subjects instead contribute to one global public goods and two local public goods. The other features of this treatment are identical to those described in the Centralisation treatment.

The second dimension is the salience of local group identities. In the Identity treatment, we use a different procedure for the formation of local groups. Remember that without the Identity treatment, local groups were randomly constructed. When the Identity treatment is applied, groups were constituted based on the proximity of the subjects' opinions in a preliminary questionnaire. Each local group is formed with subjects that share the closest opinions.

Overall, we therefore obtain four different treatment groups: centralisation without local identity, centralisation with local identity, decentralisation without local identity, and decentralisation without local identity. Our experimental design tests the effects of the treatments

[2]We control for order effects by switching the order of Parts 1 and 2 in half of the sessions.

on contribution levels and on the probability of votes for secession. In our paper, a vote for secession is defined as a vote for the institutional arrangement that includes only local public goods.

Our results show that the Decentralisation treatment increases the contributions to the local public goods. Regarding the votes, the Decentralisation treatment decreases the probability that subjects vote for secession, indicating that when subjects have more interactions with their smaller group, they are less likely to vote for a secession. This result is true even net of the effect of contributions on votes. Indeed, we also find that subjects vote less for secession when the global group is more cooperative, and vote more for secession when the local group is more cooperative. Finally, the Identity treatment does not affect significantly the level of individual contributions, nor the votes of subjects.

The remainder of the chapter is organised as follows. Section 2 surveys the related literature. Section 3 describes the experimental design and procedures and states our predictions. Section 4 reports the experimental results, while Section 5 briefly discusses them and concludes.

4.2 Related Literature

This chapter relates to several strands of the economic literature, including experimental papers with multiple public goods, experimental papers in which subjects endogenously choose their groups, as well as the experimental literature on group identity. This section will review some important contributions from these different strands.

This chapter is related to other experimental papers that study contribution behaviour under multiple public goods games. These papers include one by Bernasconi et al. (2009), who explore how contributions differ when a single group of subjects contributes to one public good or to multiple public goods. They show that the aggregated contributions of the subjects increase when a single public good is later split into two identical public goods. In this chapter, we also split our public goods in multiple identical public goods (for example, some subjects will contribute to two local public goods). However, in our case, the *total* number of goods is always three.

McCarter, Samak and Sheremeta (2013) also run an experiment where subjects are facing two public goods. Instead of varying the number of public goods, they vary the how subjects are matched with each other. In one treatment, subjects play both public goods with the same group of players, while in the other treatment, subjects play each public good with a different group of players. Their results support the idea that individuals are conditional cooperators. Indeed, participants matched with different groups shift their contributions towards the more cooperative group. This result will be important in the analysis of our experiment, but we differ from their experiment by having multiple public goods of one type, and by allowing subjects to choose which group(s) they wish to continue interacting with in the middle of the experiment.

Other papers look specifically at the outcomes under local and global public goods. Projects at a local level can provide more direct and larger benefits to their members than global projects that are distributed over more individuals. Additionally, interacting in local groups enables mutual monitoring and creates opportunities to gain social approval. These two factors have a positive effect on cooperation, especially because they are prerequisites of conditional cooperation (Fehr and Gächter 2000; Fischbacher et al., 2001; Gächter 2007). Thus, the return from contributing to a local public good is higher. However, individuals may prefer more efficient outcomes and choose actions that maximise social surplus. Since more individuals can contribute to the provision of a global public good, contributions to the global public goods may lead to higher efficiency.

Before looking at papers that directly analyse local and global groups, it is thus important to understand the potential effects of different marginal per capita returns (MPCR) and group sizes. The literature shows that participants in sessions with a high marginal per capita return[3] contribute more that participants in sessions with a low marginal per capita return (MPCR) (Marwell and Ames (1979); Isaac, Walker and Thomas (1984); and Isaac McCue and Plott (1985)). Furthermore, Kim and Walker (1984) and Brown-Kruse and Hummels (1993) find that participants significantly increase (decrease) their contributions when the marginal per capita return is increased (decreased) during the experiment. Regarding group size, Isaac and Walker (1988) show that increasing the group size from 4 to 10 participants (while keeping the marginal per capita return fixed) increases the average contributions of the participants. In a subsequent study, Isaac, Walker and Williams (1991) find that a group of 40 participants contributed a larger portion of their endowment than groups of 4 or 10 participants with the same marginal per capita return.

[3]The marginal per capita return (or the marginal payoff) corresponds to the factor that multiplies the total amount of contributions invested in the public good. It determines how much each participant will get for every unit invested (by any of the participants) in the public good and independently of the fact that a participant is a free-rider or not.

Turning to experiments with local and global groups, Wachsman (2002) builds a public goods experiment in which participants can allocate their endowment to a local group account with a relatively high marginal per capita return and a global group account with a lower marginal per capita return. When participants were not allowed to communicate with their local group, they allocated more resources to the global group account, suggesting that individuals assign greater importance to the potential payoff[4] of the global group account than to the higher MPCR of the local group account. When communication was allowed, subjects attempted to coordinate their contributions to the global group account with members of the other local groups.

Our experiment does not allow communication, so it is closer to the work of Fellner and Lünser (2008). In their experiment, they find that stable cooperation is only achieved for the local public good. Individuals first attempt to cooperate for the global public good, especially when it has a higher potential payoff (they vary the MPCR of the global account), but this tendency rapidly collapses and cooperation builds up and remains stable in the provision of the local public good instead. Fellner and Lünser (2008) only provide subjects with information on the contributions from local group members, reflecting how it is easier to monitor local group members. In turn, this helps explain their results: cooperation was more sustained in local groups. In contrast, our experiment provides feedback on contributions by both groups. Notably, subjects are able to observe whether their fellow local group members contribute significant amounts to the global good as well as the local good.

Blackwell and McKee (2003) also study contributions to local and public goods, while varying the returns of one of the accounts. The local account has a marginal per capita return of 0.3 that remains fixed through all the sessions while the global account has a return that varies across treatments, taking on four possible values: 0.1, 0.15, 0.2, and 0.3. They introduce the concept of average per capita return (APCR) for the comparison of the relative payoffs from the global public good and local public goods.[5] The results indicate that when the APCR of the global public good exceeds the APCR of the local public good, individuals contribute more to the global public good but do not reduce their contributions to the local public good. Blackwell and McKee (2011) also find that individuals contribute more to a local public good (with a smaller group), even across three different cultures: US, Russia, and Kazakhstan.

[4]The potential per capita return (or the potential payoff) corresponds to the maximal possible payoff each participant can get from a public good when all participants contribute the totality of their endowment. It is positively correlated to the number of participants playing the public good game.

[5]The APCR a theoretical tool only, expressing how much a subject in the whole session receives, on average, for each token contributed to the good.

Finally, Nitta (2014) investigates individuals' simultaneous contributions to a local and a global public good with heterogeneous endowments. His key finding is that overall contributions are higher when endowments are homogeneous across local groups (i.e., every subject receives the same endowment). Interestingly, when endowments are heterogeneous (i.e., endowments vary by local group), subjects contribute more the local public good and less to the global public good. In our experiment, we do not consider differences in endowment, focusing instead on the role of different institutional arrangements.

Other papers let subjects choose, to some degree, their membership to groups. One example is Page et al. (2005), who find that voluntary association can mitigate the free-rider problem. Indeed, in their experiment, subjects sorted themselves into groups of high and low contributors. Charness and Yang (2014) also let subjects form endogenous groups via voting: groups can be merged, individuals can be cast out, and individuals can "secede" from their group. They also find that such institutions can increase contributions. In contrast to these two examples, subjects in our experiment have less freedom in choosing their fellow group members. We impose such a feature deliberately, mimicking how real-world secessions can usually only be done by pre-determined regions. Indeed, it would be virtually impossible for many non-contiguous sub-regions to secede *together* from a larger country, for example.

Finally, this chapter is related to the literature in both psychology and economics about group identity and how it affects contribution behaviour. For instance, Campbell (1958) argues that grouping individuals into a reference group enhances cooperation amongst members of the group. Later, Hoffman, McCabe and Smith (1996), Dufwenberg and Muren (2006), Buchan, Johnson and Croson (2006), and Ahmed (2007) have shown that group identity as well as social distance, defined as the perceived affinity and nearness between people or groups, are important factors of the economic decision-making. Luttmer (2001) shows, empirically, that individuals may dislike providing social welfare when recipients are of another ethnic group, while Falk et al. (2013) bring evidence that individuals have a differentiated cooperative attitude towards the different groups they are affiliated with. Similarly, Carpenter and Cardenas (2011) report evidence of a significant change in the behaviour of individuals in a common pool resource game depending on the cultural diversity within the group.

Even in situations in which individuals have been assigned to groups based on arbitrary characteristics, they treat the members of their group differently than members of other groups (Festinger 1954; Tajfel et al. 1971; Tajfel 1974; Tajfel and Turner 1979). Tajfel (1970) named this experimental technique the minimal group paradigm. Following the minimal group paradigm of Tajfel (1970), Chen and Li (2009) and Chakravarty and Fonseca (2012) study the effects of induced group identity on social preferences and public good provision, relying, in their experimental designs, on artificially-induced identities. They introduce identity through an arbitrary task completely unrelated to the main focus of the experiment. Subjects were asked to review the paintings of two modern artists, Paul Klee and Wassily Kandinsky. Groups were formed according to the preferences of the participants for these two artists. In our experimental design, we have two degrees of local group identity. First, when individuals are placed in three local groups randomly, we may assume, based on the minimal group paradigm, that our experimental design induced a local group identity. To reinforce this local group identity, we apply a second treatment in which subjects were asked to answer a short questionnaire, and were then grouped with the 2 other subjects (out of 9) that expressed the opinions nearest to theirs.

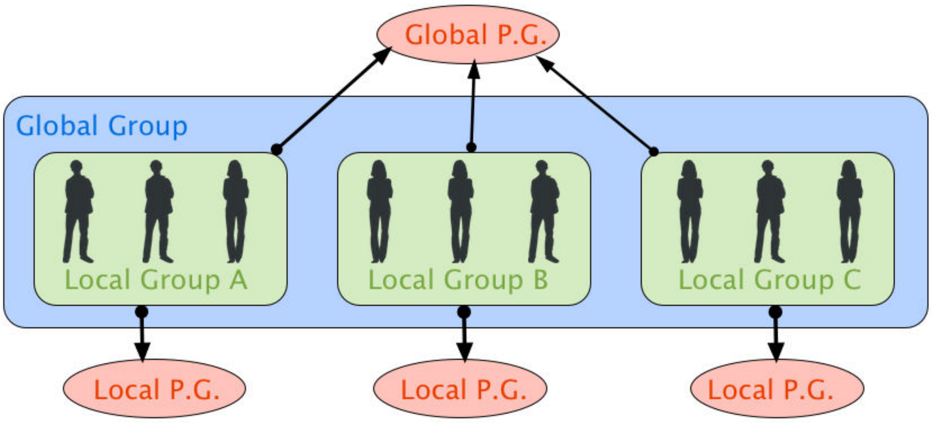
4.3 The Experiment

Our experiment employs a 2×2 research design. We thus have a total of 4 treatment groups, differing on two dimensions. The first treatment dimension is the configuration of the public goods (decentralization or not), and the second is the creation of local group identity. In each treatment participants interacted under a partner matching protocol.

4.3.1 The Baseline Experimental Protocol

We first describe the basic experimental protocol, used in the sessions where there was no decentralisation or local identity (i.e., the Baseline treatment, or, as will be introduced later, the Cent-NI treatment). Before the start of the first part the computer program forms randomly groups of 9 subjects. Each group of 9 subjects is composed of three sub-groups of 3 subjects. A group of 9 subjects is called a “global group” and a sub-group of 3 subjects a “local group”. A global group thus comprises 3 local groups labelled A, B and C. Each subject is at the same time a member of a local group with 2 other subjects and a member of a global group that includes his local group and the 6 members of the two other local groups (see Figure 4.1).

A session consists of 36 periods divided in three parts of 12 periods each. In each part subjects can contribute to three public goods. Public goods are either local or global. Two main differences distinguish local public goods from global public goods. First, their potential



Note: This figure illustrates the formation of the groups. It shows how the three local groups are embedded in a global group. Arrows represent contributions to public goods. Subjects of different genders are randomly assigned to groups.

Figure 4.1: Formation of Local and Global Groups

contributors are different. While only 3 subjects can contribute to a local public good, all 9 subjects can contribute to the global public good. Consequently, the global public good has a higher social return. Second, local and global public goods have different marginal per capita returns (MPCR). Namely, the MPCR is 0.5 for the local public goods and 0.2 for the global public goods. Thus, each Experimental Currency Unit (ECU) allocated to a local group account pays back 0.5 ECU while each ECU allocated to a global group account pays back 0.2 ECU. At the beginning of each period, each participant receives an endowment of 60 ECU to allocate between a private account, a local group account and a global group account. Participants can allocate all of the 60 ECU endowment to a single account (and 0 to the others), or split it between multiple accounts. The private account yields a one-to-one return. Players do not observe contribution decisions of any other player before they make their own choices. The payoff of subject i, π_i, equals:

$$\pi_i = (60 - c_i) + 0.5 \sum_{j=1}^{3} c_j + 0.2 \sum_{k=1}^{9} c_k$$

where c_i is player i's contribution to the local and global public goods, and c_j and c_k that of each local group member, $j = 1, 2, 3$ and global group member, $k = 1, ..., 9$.

In the first part of the Baseline treatment, at each period players have to choose how many ECU of their endowment (between 0 and 60) to contribute to the unique local group account and to two global public accounts, with the remainder kept in their private account. The total amount contributed to the local public account times the MPCR is shared equally among the 3 local group members while the total amount contributed to the global public accounts times the MPCR is equally shared among the 9 global group members (see instructions in the appendix for snapshots of computer screens displayed to participants).

After each period, each participant is informed of his individual contributions to each one of the three public goods, his payoff, the total contributions of the global group to each good, and the total contributions of the local group to each good (i.e., both local and global goods). Participants are not informed of the contributions by the members of the two other local groups of which they are not members.

In the 12 periods of the second part of the Baseline treatment subjects can contribute to 3 local public goods. There is no more global public goods. At each of the 12 periods players have to choose how to allocate their endowment between these three local group accounts and their private account.

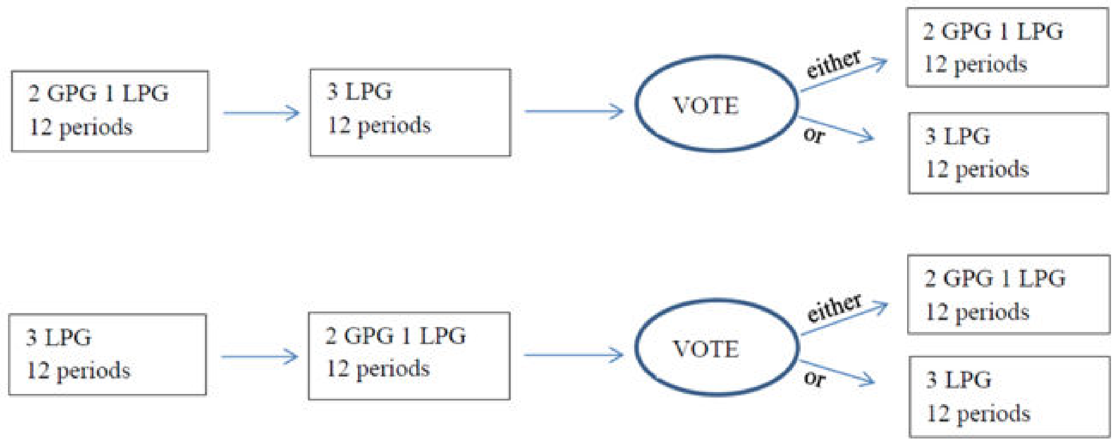
After having experienced the settings of part 1 and part 2, subjects are asked at the beginning of the third (and last) part to express their preference for one of these two configurations with a vote between two options:

- The option with one local group account and two global group account (as in part 1)
- The option with three local group accounts (as in part 2).

Subjects can answer yes to only one of these two options. The final outcome of the vote is based on a double majority rule. Concretely, the computer program first determines how many members voted in favour of three local public goods in each local group. The majority is attained when two members out of three voted for that configuration. Then, the computer calculates how many local groups attained a majority in favour of that situation. Again, majority is reached when two local groups out of three voted for the same situation. The third part of the experiment is the application of the configuration that won the vote to all local groups.

A double majority rule was necessary to ensure that subjects would end up in a configuration they already experienced, namely either public goods with only the members of their local group, or public goods with both the members of their local groups and all 8 other members of the global group. Allowing a single local group to secede would create global groups of six people only, which would be a completely new situation for the subjects and bring additional uncertainty. Concretely, a double majority rule resembles decentralised countries such as Switzerland, for instance, where the use of double majority rule is common in referendums and popular initiatives. It also captures some aspect of secession decisions in countries such as Canada, which adopted a law that allows some level of federal oversight in the decision of provinces to secede.

Finally, to account for the effect of the order in which parts 1 and 2 are played on the outcome of the vote, each treatment is conducted with parts 1 and 2 inverted. Figure 4.2 schematises the parts of the experiment.



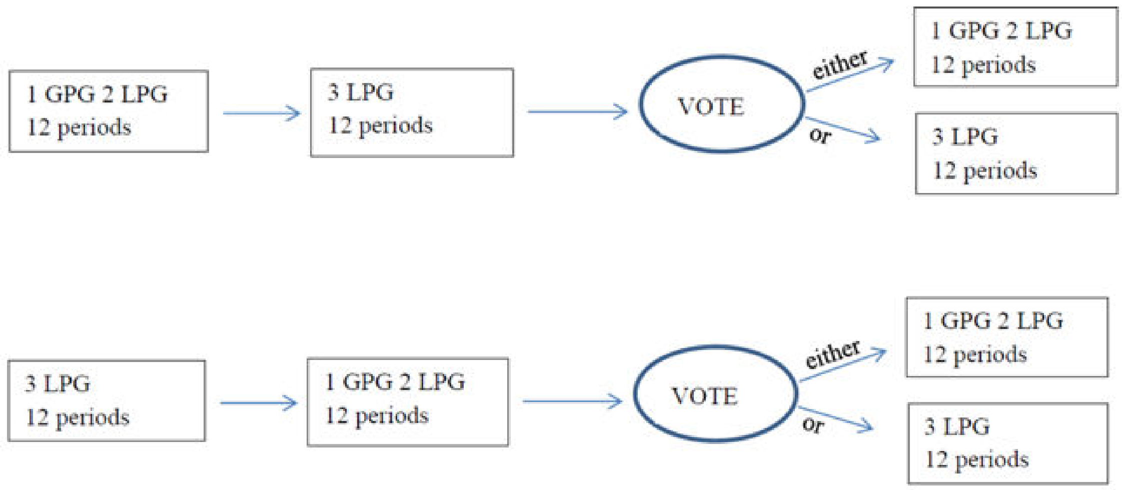
Note: GPG and LPG stands for global public goods and local public goods, respectively.

Figure 4.2: The Basic Experimental Protocol

4.3.2 The Decentralization Treatment

The difference between the Baseline and Decentralization treatments is the number of public goods in each category. Instead of two global public goods and one local public good, there will be one global public good and two local public goods. As a result, players at each period have to choose how many ECU of their endowment (between 0 and 60) to contribute to the two local group accounts and to the unique global group account, with the remainder kept in their private account.

All the other features of the Decentralization treatment are identical to those of the Baseline treatment. This treatment aims at testing whether individuals vote differently at the beginning of the third stage after experiencing a different configuration where more local group accounts are available. Figure 4.3 schematises the Decentralization treatment.



Note: GPG and LPG stands for global public goods and local public goods, respectively.

Figure 4.3: The Experimental Protocol Under the Decentralisation Treatment

4.3.3 The Identity Treatment

The difference between the Baseline and the Identity treatments is the reinforcement of local identity, prior to the procedure as explained above. As the literature shows (Festinger 1954; Tajfel et al. 1971; Tajfel 1974; Tajfel and Turner 1979), placing participants of an experiment in random groups and simply labelling those groups already creates group identity. Thus, even when we do not apply the Identity treatment, members of local groups already share a local group identity. The Identity treatment reinforces this local group identity and tests how it affects the outcome of the vote. In particular, we test if emphasising local group identity increases the tendency of subjects to vote for secession (i.e., in favour of three local public goods).

As in previous treatments, at the beginning of the experiment the computer program randomly forms groups of 9. But in the Identity treatment, subjects are not assigned randomly to local groups. Instead, they are grouped according to a measure of their general preferences (arts, sports, etc.).

Prior to the first part of the experiment, subject respond to a short questionnaire. The questionnaire contained four statements to which subjects were asked to give an appreciation by selecting one of the four following options: 1. I strongly disagree, 2. I disagree, 3. I agree, and 4. I strongly agree.[6] Once the questionnaire is completed the computer program used an algorithm to form the local groups according to the proximity of the answers given to the

[6]The statements in the questionnaire covered subjects unrelated to the experiment. See the instructions in the appendix for a detailed presentation of the questionnaire.

different statements.

At the local level, each subject is thus paired with the two other subjects that, among the overall group of 9 subjects, express the opinions nearest to his. As a result, each local group is formed with subjects that share the closest opinions. Consequently, from the point of view of each local group, members of the other two local groups have opinions more distant to them. All the other characteristics of the Identity treatments are identical to the Baseline and Decentralization treatments.

4.3.4 Predictions

In all treatments, assuming that players maximise their own earnings, the sub-game perfect equilibrium is to not contribute at all to the public goods, regardless of the category. Indeed, the marginal per capita returns of both types of public goods are always lower than the marginal return of the private goods. In contrast, the socially optimal behaviour is to contribute entirely to the global public good, as $0.5 \cdot 3 > 1$ as well as $0.2 \cdot 9 > 1$. However, as previous laboratory experimental studies on public good games reported that individuals do, generally, contribute to the public good (Ledyard, 1995), our first prediction is that contributions to both categories of public goods will not be zero.

Hypothesis 4.1.A. *Individuals will contribute positive amounts to both categories of public goods.*

The next hypothesis pertains to how individuals behave within local and global groups. To the extent that the subjects identify more as a member of their local group, they will have a preference for contributing to local public goods. We expect local groups to be more cohesive, leading to larger contributions to local public goods. Fellner and Lünser (2008), for example, show that cooperation is easier to sustain in the smaller group. Free riding in local groups is also easier to detect and, consequently, less likely to occur. For these reasons, in addition to a higher MPCR, we hypothesise that individuals will contribute more to local public goods.

Hypothesis 4.1.B. *Individuals will contribute more to the local public goods.*

The next two hypotheses concern the effect of the treatments on the contribution behaviour of the subjects. First, we make the hypothesis that the Decentralisation treatment will incite greater contributions to the local goods. Bernasconi et al. (2009) show that subjects contribute more when there are two public goods than a single one. Therefore, we expect that contributions will be higher to any given type of good when subjects face multiple goods of that type. This hypothesis translates how decentralisation usually implies more spending and public goods at the local level.

Hypothesis 4.2.A. *The Decentralisation treatment will lead to more contributions to the local public goods.*

Similarly, we make the hypothesis that the Identity treatment will incite greater contributions to local goods. Indeed, as subjects identify with other members of the local group more strongly, we expect that they will contribute more, and that this cooperation will be easier to sustain.

Hypothesis 4.2.B. *The Identity treatment will lead to more contributions to the local public goods.*

We are ultimately interested in the effect of the treatments on the probability of secession votes. Regarding the Decentralisation treatment, there are two effects at play. The first effect operates through contributions. If, under decentralisation, contributions to the local public goods are higher, subjects might be more likely to vote for secession. Indeed, faced with a relatively more cooperative local group, subjects might decide they prefer only having local goods. However, having a cooperative local group might reduce the need for subjects to leave the global group. There might also be an effect net of contributions, although the direction is ambiguous, as explained in the motivation to the chapter. We predict that decentralisation will reduce the probability of votes for secession.

Hypothesis 4.3.A. *The Decentralization treatment will decrease the probability for a group to break up.*

Regarding the Identity treatment was designed to emphasise local group identity. Therefore, we expect that this treatment will increase the probability of secession votes.

Hypothesis 4.3.B. *The Identity treatment will increase the probability of secession votes.*

Following the argument of Ezgi (2009), we also test whether decentralisation and local identities have synergistic effects on the decision to secede. Indeed, the desire of a local group (or, in the real world, a region) to secede might be due to the widespread free-riding in the global group, or to the fact that subjects in the local group feel closer to one another (for example, when we apply the Identity treatment). For that reason, decentralisation could be less efficient at reducing secession votes when we reinforce local identities.

Hypothesis 4.3.C. *The Identity treatment will reduce the effect of the Decentralisation treatment on the probability of secession votes.*

We also hypothesise that contributions by other members of both groups will affect the individuals' votes for secessions. In particular, when local group members contribute more to public goods, it should incite more votes for secession. Indeed, it allows subjects to choose the group members that they know are cooperators. Conversely, if global group members contribute more to public goods, it should incite fewer votes for secession. Indeed, as the global goods have potentially greater payoffs (given the larger number of participants), subjects that experience a more cooperative global group will choose to continue sharing public goods with that group.

Hypothesis 4.4. *Greater contributions to public goods by other members of the local (global) group increases (decreases) the probability of a secession vote.*

4.3.5 Procedures

The experiment consists of 33 sessions conducted at the GATE-LAB research institute located in Lyon, France. The 432 participants were recruited from local engineering and business schools, using the ORSEE software (Greiner, 2004). No subject participated in more than one session. 55.79% of the participants are females and their mean age is 22.97 years ($S.D. = 6.22$). We organised three sessions per treatment. To account for the effect of the order in which parts 1 and 2 are played on the outcome of the vote, three supplementary sessions were organised for each treatment with parts 1 and 2 inverted. This results in a total of six sessions per treatment. 108 participants took part in each treatment. The experiment was computerised using the ZTree software package (Fischbacher, 2007). Table 4.1 summarises the characteristics of the experimental sessions.

Upon arrival, participants were randomly assigned to a computer after drawing a tag from an opaque bag. Sets of instructions were distributed at the beginning of each part and read aloud. On average a session lasted 90 minutes, including payment. The participants were paid the sum of their earnings in each period, at the rate of 100 Experimental Currency Units = 0.45 Euro. In addition, they were paid a 5 Euro show-up fee. On average, participants earned 17.12

Table 4.1: Characteristics of the Experimental Sessions

Session Number	Number of Participants	Treatment Name	Decentralisation	Identity	Order
1	18	Cent-NI	No	No	Mixed first
2	18	Cent-NI	No	No	Mixed first
3	18	Cent-NI	No	No	Mixed first
4	18	Decent-NI	Yes	No	Mixed first
5	18	Decent-NI	Yes	No	Mixed first
6	18	Decent-NI	Yes	No	Mixed first
7	9	Cent-NI	No	No	Three Local First
8	18	Cent-NI	No	No	Three Local First
9	18	Decent-NI	Yes	No	Three Local First
10	18	Decent-NI	Yes	No	Three Local First
11	9	Cent-NI	No	No	Three Local First
12	18	Cent-NI	No	No	Three Local First
13	9	Decent-NI	Yes	No	Three Local First
14	9	Decent-NI	Yes	No	Three Local First
15	9	Cent-I	No	Yes	Mixed first
16	9	Cent-I	No	Yes	Mixed first
17	9	Decent-I	Yes	Yes	Mixed first
18	9	Decent-I	Yes	Yes	Mixed first
19	9	Cent-I	No	Yes	Mixed first
20	9	Cent-I	No	Yes	Mixed first
21	9	Cent-I	No	Yes	Mixed first
22	9	Cent-I	No	Yes	Mixed first
23	9	Decent-I	Yes	Yes	Mixed first
24	9	Decent-I	Yes	Yes	Mixed first
25	9	Decent-I	Yes	Yes	Mixed first
26	18	Decent-I	Yes	Yes	Three Local First
27	18	Cent-I	No	Yes	Three Local First
28	9	Decent-I	Yes	Yes	Three Local First
29	9	Cent-I	No	Yes	Three Local First
30	9	Cent-I	No	Yes	Three Local First
31	18	Cent-I	No	Yes	Three Local First
32	18	Decent-I	Yes	Yes	Three Local First
33	18	Decent-I	Yes	Yes	Three Local First
Total	432				

Note: The "Order" column refers to the order of the first two parts of the experiments. All subjects experienced 12 periods with a mix of local and global public goods and 12 periods with only local goods. The difference was in the ordering. Some sessions started in Part 1 with a mix of local and global public goods, while others started Part 1 with only three local goods.

Euro ($S.D. = 1.68$). Payments were made individually in cash and in private in a separate room.

At the end of the experiment, we administered a demographic questionnaire including questions on gender, age, and relative wealth of the family compared to other students (on a scale from 0 for the poorer to 10 for the wealthier).

4.4 Results

Our experiment yielded these main results:

4.1.A (Contributions) Subjects contribute non-null amounts to public goods

4.1.B (Contributions) Subjects contribute more to local goods.

4.2.A. (Contributions) The Decentralisation treatment increases contributions to local goods, but has no effect on contributions to global goods.

4.2.B. (Contributions) The Identity treatment has no effect on individual contributions.

4.3.A. (Vote) The Decentralisation treatment decreases the probability of a secession vote.

4.3.B. (Vote) The Identity treatment has no effect on the probability of a secession vote.

4.4. (Vote) The probability of a secession vote is increased when local group members contribute more, but decreased when global group members contribute more.

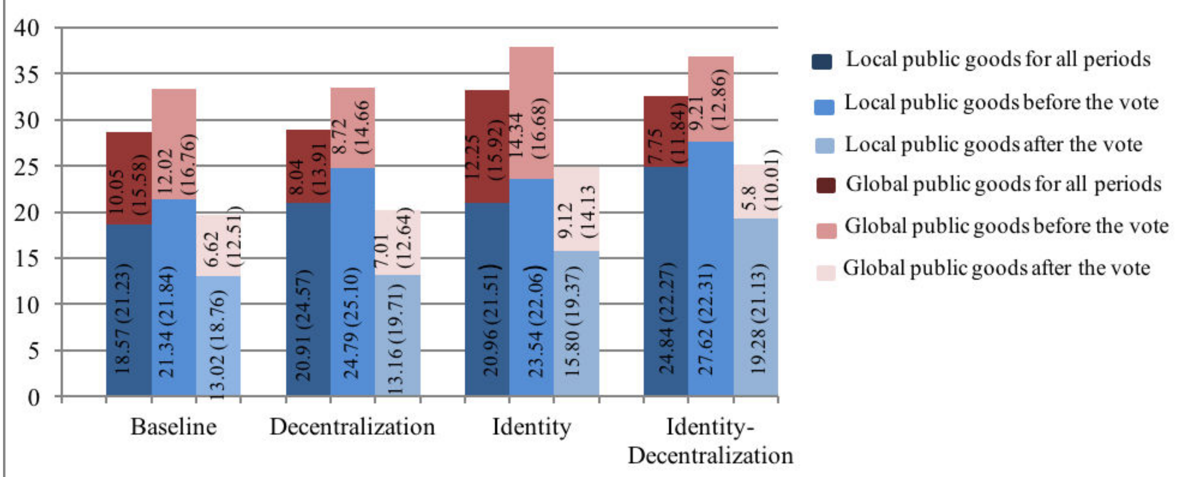
4.4.1 Preliminary Results on Contributions

Figure 4.4 illustrates the average individual contributions to local public goods (in blue) and to global public goods (in red) in the four treatment categories for all periods (periods 1 to 36), for periods before the vote (periods 1 to 24), and for those after the vote (periods 25 to 36).

First, note that contributions are positive on average, thus replicating the usual result of public good games:

Result 4.1.A. *Subjects contribute non-null amounts to the public goods.*

Figure 4.4 also shows that (in all treatments) average individual contributions to both types of goods are higher before the vote, when the institutional arrangement is exogenously imposed. Therefore, implementing a setting that was decided endogenously by a vote did not encourage the subjects to increase their contributions at a level higher than before the vote. Wilcoxon



Note: In blue we highlighted the average individual contributions to local public goods and in red the average individual contributions to global public goods. We consider all periods taken together (represented in dark blue and red), the periods before the vote (represented by middle blue and red), and for the periods after the vote (represented by light blue and red). Numbers indicate mean values. Standard errors are in parentheses.

Figure 4.4: Average Individual Contributions by Types of Goods, Treatment, and Block of Periods

tests (W, hereafter) at the global group level confirm that, in all the treatments, the mean individual contributions (both to local and public goods) before the vote and in the last 12 periods after the vote are significantly different (W tests local goods: Cent-NI $p = 0.0037$; Decent-NI $p = 0.0029$; Cent-I $p = 0.0076$; Decent-I $p = 0.0060$. W tests global goods: Cent-NI $p = 0.0180$; Decent-NI $p = 0.01117$; Cent-I $p = 0.01117$; Decent-I $p = 0.0077$).

Figure 4.5 shows the evolution in average individuals contributions across the 36 periods, separately for the two orders in which the experiments took place. In shades of red, it shows average individual contributions when the experiment started with both types of public goods. In this environment, subjects initially contribute more to local public goods, and there is a large restart effect in Period 13, when subjects were faced only with local public goods. In that environment, we observe a large restart effect after the vote, but only in cases where subjects actually seceded (dashed line). Cooperation persists a few periods until breaking down in the last periods. In blue and black, Figure 4.5 shows the results for the other ordering of the experiment. Here, subjects initially contribute large amounts to local public goods in the first 12 periods, even more than those who also had public goods available, but we do not observe a restart effect at Period 13. While contributions to the global goods initially surpass those to the local goods, the pattern is reversed after a few periods. In that environment, a secession induces a similar important restart effect for contributions to the local goods (dashed line), although cooperation is less persistent. For both orderings, contributions to global goods follow a similar pattern in Periods 25 to 36.

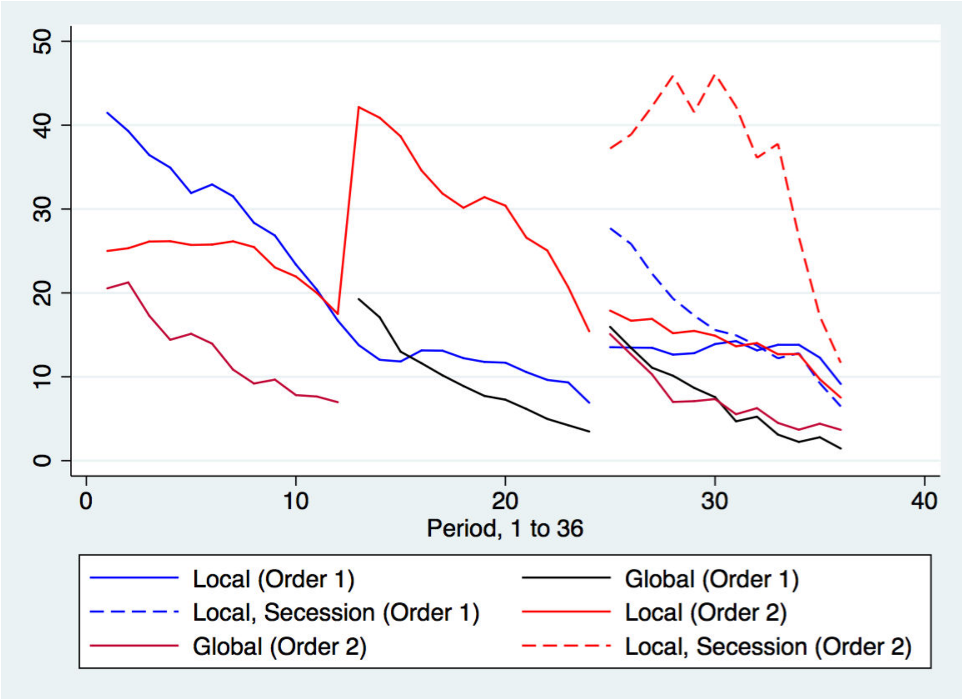


Figure 4.5: Average Individual Contributions Across All Treatments, for Both Experimental Ordering (by Period)

Figure 4.5 shows one result is common to both orderings of the experiment, in almost every period:

Result 4.1.B. *Subjects contribute more to local goods.*

4.4.2 The Effect of the Treatments on Contributions

Table 4.2 compares contributions across treatments. First, it displays the average contributions to each category of public good over each sequence of 12 periods. It also displays the average percentage of maximum efficiency reached in each global group for each category of public good, for the three parts of the experiment (12-period block).

Table 4.2 shows that contributions differ mostly between the two extreme cases: decentralisation with local identity, and centralisation without local identity (Decent-I vs. Cent-NI). Indeed, two-tailed Mann-Whitney[7] tests—MW, hereafter—comparing these two treatments indicate that contributions to the local goods are higher in the first 12 periods in the Decent-I

[7] An independent observation corresponds to the contributions of each global group averaged over each sequence of 12 periods.

Table 4.2: Summary Statistics on Contributions, by Treatment and Block of Periods

Variables	Periods	Cent-NI	Decent-NI	Cent-I	Decent-I
Contributions to local public goods	1-12	22.79 (9.77)	28.69 (9.11)	26.23 (7.67)	31.02 (3.93)**
	12-36	19.93 (10.82)	18.98 (10.93)	20.85 (12.09)	24.20 (10.59)
	25-36 (secession)	17.36 (8.81)	9.49 (2.82)	21.28 (6.09)	24.07 (8.10)
	25-36 (no secession)	9.93 (3.45)	13.69 (5.90)	13.06 (6.53)	17.14 (5.92)**
Contributions to global public goods	1-12	15.92 (3.43)	10.06 (4.69)	15.04 (4.79)	10.53 (5.34)
	12-36	8.38 (5.28)	7.97 (5.85)*	13.63 (4.84)*	7.95 (1.89)
	25-36 (no secession)	6.62 (3.81)	7.01 (4.42)	9.12 (4.39)	6.34 (4.15)
Average percentage of maximimum efficiency reached inb local public goods (%)	1-12	37.98	47.82	43.71	44.84**
	12-36	33.22	31.64	34.75	36.77
	25-36 (secession)	28.93	15.81	35.46	33.12
	25-36 (no secession)	16.55	22.81	21.8	23.31**
Average percentage of maximimum efficiency reached inb global public goods (%)	1-12	8.84	5.59	8.35	7.35
	12-36	4.65	4.42	7.57	4.53
	25-36 (no secession)	3.67	3.89	5.06	3.59

Numbers indicate mean values. Standard deviations are in parentheses. The significance levels of two-tailed Mann–Whitney tests are represented by ***, **, and *, with p<0.01, p<0.05, p<0.10, respectively, in which we compare each treatment to the Cent-NoID treatment. Each bloc of 12 periods gives only one independent observation for each global group.

treatment (MW $p = 0.0377$), as well as in the last block of the game when no secession took place (MW $p = 0.0172$).

When administering the Decentralisation or Identity treatment alone, we only obtain significant differences on contributions to global public goods in periods 13 to 24. For the Decentralisation treatment alone, the difference is significant at the 10% level (MW test, $p = 0.0547$), similarly for the Identity treatment alone (MW $p = 0.0782$).

The last two sections of Table 4.2 describe the average percentage of maximum efficiency reached for each type of public goods. Notably, it shows that efficiency for local goods is higher in the Decent-I treatment (decentralisation with local identities) than in the Cent-NoID treatment, at least for the first and last 12 periods (without a secession).

To further analyse the determinants of contributions, Table 4.3 presents the estimations from OLS models using random effects on our panel of 144 local groups, with standard errors clustered at the local level (local groups are fixed throughout the session). The data only includes contributions in periods 1 to 24, before the vote. Moreover, it only includes periods in which both types of goods are available to the subjects.

In all the models our variables of interest are the dummy variables indicating the administration of the Decentralization and Identity treatments. We are also interested in the effect of the previous contributions of fellow group members. In addition, we control for the order in which parts one and two were played by adding a supplementary dummy that takes one when the experimental secession started with three local public goods. We also add a time trend and control for various individual characteristics (age, gender and the wealth level).

In the first and second columns of Table 4.3, the dependent variables are individual contributions to the local and global public good, respectively. In the third column, the dependent variable is the difference between the contributions to the local good and those to the global good (i.e., the individual's bias towards the local goods).

Table 4.3: Determinants of Individual Contributions to Local and Global Goods, and of the Difference Between Contributions to Each Type

	Contributions to Local Goods	Contributions to Global Goods	Difference Between Local and Global
Decentralisation	3.2187**	-1.8997	4.9801**
	(1.64)	(1.52)	(2.04)
Local Identity	0.3943	1.4654	-1.0561
	(1.47)	(1.44)	(1.69)
Interaction Effect	1.9789	-0.9133	2.8345
	(2.18)	(1.98)	(2.54)
Start with 3 Local Goods	-7.1442***	-2.7897***	-4.2385***
	(1.30)	(1.03)	(1.46)
Contributions by others	0.2147***	-0.0213*	0.2428***
to Local Goods (lagged)	(0.02)	(0.01)	(0.02)
Contributions by others	0.0019	0.0329***	-0.0330***
to global goods (lagged)	(0.01)	(0.01)	(0.01)
Period	-0.4137***	-0.9090***	0.4785***
	(0.11)	(0.10)	(0.16)
Age	0.0304	0.2448***	-0.2155*
	(0.10)	(0.07)	(0.12)
Gender	1.4869	1.7623**	-0.2712
	(1.06)	(0.87)	(1.22)
Wealth Level	-0.4204	-0.3816*	-0.0331
	(0.27)	(0.22)	(0.29)
Constant	14.3151***	11.6228***	2.7646
	(3.21)	(2.68)	(4.01)
N	4752	4752	4752
R^2	0.339	0.149	0.208
χ^2	570.4***	357.7***	301.4***

Clustered standard deviations in parentheses. Significance levels: *** (p<0.01), ** (p<0.05), and * (p<0.10).
Estimations only include periods in which subjects had to contribute to both types of goods.

The first column shows that the Decentralization treatment increases individual contributions to local goods, but the second column shows that this treatment has no effect on contributions to global goods. Put differently, when faced with two local goods, subjects increase their contributions to that good, but the opposite is not true: when faced with two global goods, subjects do not increase their contributions to those goods. Finally, the third column shows that decentralization increases contributions to the local good relative to the global good. We can summarise the results as such:

Result 4.2.A. *The Decentralisation treatment increases contributions to local goods, but has no effect on contributions to global goods.*

The contributions of fellow group members also affect contributions to public goods. In particular, the third column shows that as members of an individual's local group contribute more to the local good, that subject then contributes relatively more to the local good. Conversely, as members of an individual's global group contribute more to the global good, he or she contributes relatively more to the global good.

The time trend has a negative effect indicating that individual contributions declined over time, as expected. However, the time trend positively affects the relative contribution to the local goods, indicating that as time advances, individuals contribute relatively more to the local goods. The order in which parts one and two are played significantly affects contributions to both types of public goods.

Table 4.4: Marginal Effects of the Decentralisation Treatment, at Both Values of the Identity Dimension

	Contributions to Local Goods	Contributions to Global Goods	Difference Between Local and Global
M.E. of Decentralisation under:			
Reinforced Local Identity	5.1976***	-2.8130**	7.8146***
	(1.53)	(1.52)	(1.70)
No Reinforcement of Local Identity	3.2187**	-1.8997	4.9801**
	(1.64)	(1.28)	(2.04)
χ^2 (Wald test: equality of coefficients)	0.07	1.03	0.39

Standard deviations in parentheses. Significance levels: *** (p<0.01), ** (p<0.05), and * (p<0.10).

Our regressions included interaction effects between the two treatments, to test whether the increased saliency of local identities affected the effect of the Decentralisation treatment. Table 4.3 shows that the interaction term is not significant. Table 4.4 shows that the marginal effects of the Decentralisation treatment are amplified by the reinforcement of local identity. However, Wald tests indicate that the differences in the coefficients are not statistically significant. This result, along with those of Table 4.3, are summarised as follows:

Result 4.2.B. *The Identity treatment has no effect on individual contributions.*

4.4.3 The Effect of the Treatment on Votes for Secessions

We turn now to the analysis of the subjects' votes, taking place before the third part of the experiment. First, note that 159 subjects voted for secession, or 36.8 per cent of all subjects. These votes translated into secessions in 16 global groups.[8]

Table 4.5: Determinants of Votes for Secession (Probit Coefficients and Marginal Effects)

	(1) Probit	(2) M.E.	(3) Probit	(4) M.E.	(5) Probit	(6) M.E.
Decentralisation	-0.3062	-0.1361***	-0.3124	-0.1375***	-0.2969	-0.1279***
	(0.19)	(0.04)	(0.19)	(0.04)	(0.19)	(0.04)
Local Identity	0.0618	-0.0252	0.0646	-0.0246	0.0747	-0.0170
	(0.21)	(0.04)	(0.21)	(0.04)	(0.21)	(0.04)
Interaction Effect	-0.2867		-0.2892		-0.2608	
	(0.28)		(0.28)		(0.28)	
Start with 3 Local Goods	1.0214***	0.3105***	1.0297***	0.3110***	1.0088***	0.3018***
	(0.16)	(0.04)	(0.16)	(0.04)	(0.16)	(0.04)
Average Individual Contributions	0.0038	0.0012	0.0075	0.0023	0.0134*	0.0040*
to Local Goods	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Average Individual Contributions	0.0080	0.0024	0.0022	0.0007	0.0000	0.0000
to Global Goods	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Average Profits, Local Goods	0.0126	0.0038				
	(0.01)	(0.00)				
Average Profits, Global Goods	-0.0656***	-0.0200***				
	(0.02)	(0.01)				
Average contributions from local group members to:						
All Public Goods			0.0080**	0.0024**		
			(0.00)	(0.00)		
Local Public Goods					0.0019	0.0006
					(0.00)	(0.00)
Global Public Goods					0.0182***	0.0054***
					(0.01)	(0.00)
Average contributions			-0.0078***	-0.0023***	-0.0107***	-0.0032***
from global group members			(0.00)	(0.00)	(0.00)	(0.00)
Age	-0.0032	-0.0010	-0.0035	-0.0010	-0.0023	-0.0007
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Female	0.5685***	0.1728***	0.5758***	0.1739***	0.5757***	0.1722***
	(0.14)	(0.04)	(0.14)	(0.04)	(0.14)	(0.04)
Wealth Level	0.0291	0.0088	0.0299	0.0090	0.0332	0.0099
	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)
Constant	-1.1054***		-1.1218***		-1.0561**	
	(0.40)		(0.41)		(0.41)	
N	432		432		432	
Pseudo-R^2	0.182		0.187		0.197	
χ^2	90.1		90.4		89.4	

Clustered standard errors in parentheses. Significance levels: *** (p<0.01), ** (p<0.05), and * (p<0.10).

We estimate Probit models in which the dependent variable takes value 1 if an individual voted in favour of secession, i.e. in favour of three local public goods, and 0 otherwise.

[8]Our voting rule (double majority) did not allow for secession by only one local group in any given global group.

Our variables of interest are the dummy variables for each treatment dimension (Decentralization and Identity). We also include variables for the ordering of the experimental sessions (equal to 1 when it started with three local public goods), as well as for the individual's contributions and average profits from each type of good. We also control for individual characteristics (age, gender and wealth level).

Table 4.5 presents the results of the regressions, as well as marginal effects. The difference between the three models is the variable used to control for the degree of cooperation in the different groups. First, in all models, we wee that the Decentralization treatment decreases the probability that subjects vote for secession by about 13 per cent. This result is significant at the 1% level.

Result 4.3.A. *The Decentralisation treatment decreases the probability of a secession vote.*

The Identity treatment, however, does not affect the outcome of the vote.

Result 4.3.B. *The Identity treatment has no effect on the probability of a secession vote.*

Furthermore, there is no indication of a significant interaction effect between the two treatment dimensions. Table 4.6 shows the estimated marginal effects of the Decentralisation treatment at both values of the Identity dimension.

Table 4.6: Marginal Effects of the Decentralisation Treatment on Votes for Secession, at Both Values of the Identity Dimension

	Vote for Secession
M.E. of Decentralisation under:	
Reinforced Local Identity	-0.1677***
	(0.06)
No Reinforcement of Local Identity	-0.0881
	(0.06)
χ^2 (Wald test: equality of coefficients)	0.13

Standard deviations in parentheses. Significance levels: *** (p<0.01), ** (p<0.05), and * (p<0.10).

The marginal effect is only significant under the reinforced local identity, indicating that decentralisation affects votes only when the local groups' identities are made more salient. However, a Wald test finds no significant difference between the values of the marginal effects. We summarise the results on the Identity dimension as follows:

Result 4.3.C. *The Identity treatment does not modify the marginal effect of the Decentralisation treatment on secession votes.*

Regarding the control variables, we first find that subjects are more likely to vote for secession when the experiment starts with with three local public goods. Second, individual contributions have no effect on vote behaviour. Finally, among the demographic variables, gender affects voting behaviour. Namely, women vote more frequently in favour of secession. However, age and wealth level have no effect on the vote.

4.4.4 The Effect of Group Contributions to Secession Votes

The average profits from public goods also affect the votes for secession. In particular, Table 4.5 (Columns 1 and 2) shows that when subjects receive higher profits from the global public goods, the probability that they vote for secession is lower. The marginal effects of Column 2 indicate that for each additional unit of experimental currency in profit, the probability decreases by about 2 per cent. The average profits from global goods, over the 432 individuals, is of 10.1 units with a standard deviation of 5.0 units. Therefore, the coefficient is also economically significant (a reduction of 10 percentage points in the probability of a secession vote for an increase of one standard deviation in global profits). We do not find a significant effect for profits from local goods. Since larger profits from global goods indicate that the global group was more cooperative, this result suggests that a vote for secessions is less likely when the global group is cooperative.

We can also analyse contributions of others directly, instead of summarising them through average profits. Columns 3 to 6 of Table 4.5 presents the result of this analysis. We always include the contributions of other members of the global group to global public goods. Columns 3 and 4 show the result when including contributions from other local group members to *all* public goods, while Columns 5 and 6 include contributions from other local group members to both types of goods, but disaggregated.[9]

First, we see that higher contributions from global group members lead to a lower probability of a secession vote. Specifically, when global group members contribute an additional unit, the probability of a secession vote decreases by between 0.2 and 0.3 percentage points. An increase of one standard deviation in this variable (45.43 units) would decrease the probability of a secession vote by between 10.4 and 14.5 percentage points.

Second, we see that contributions from local group members have the opposite effect (Columns 1 and 2). Moreover, contributions to *global* goods from local group members increase the prob-

[9]Subjects had access to this information during the experiment.

ability of a secession vote. Indeed, Column 4 shows that an increase of one unit in contributions from local group members to global goods increase the probability of a secession vote by about 0.54 percentage points. An increase of one standard deviation in this variable (16.16 units) would increase the probability of a secession vote by 8.73 percentage points. This effect is somewhat lower than contributions from the global group. We can summarise the results as such:

Result 4.4. *The probability of a secession vote is increased when local group members contribute more, but decreased when global group members contribute more.*

4.5 Discussion and Conclusion

The question that motivates this chapter is whether devolving some responsibilities to regional governments in countries facing regional separatist movements could avoid a divide of the country. The literature does not give a clear-cut answer on the effectiveness of decentralisation as a device to quell separatist movements. Our contribution lies in the design of an original experiment that uses a public good game with multiple public goods played in different settings that capture some real-world features. We focus on the effects of a decentralised provision of public goods as well as of local group identities on the probability of votes for secession, corresponding in our design to a choice by subjects to only interact with members of their local, smaller group.

First, our results indicate that the Decentralisation treatment, where subjects have more goods with which to interact with local group members, increases the contributions to local public goods. This result is in line with the results of Bernasconi et al. (2009), who show that when faced with multiple identical public goods, subjects contribute more than faced with a single good. However, the treatment has no effect on contributions to global public goods, which goes against the results of Bernasconi et al. (2009). Overall, these results do indicate that our experiment created institutions that induced different contribution behaviour by the subjects. While a more realistic setting would probably capture the preference matching aspect of decentralised public goods provision, our institutions reflect, to some level, the fact that local goods are “closer” to voters, and more easily monitored.

Second, we find that the Decentralisation treatment decreases the probability of votes for secession. Notably, this result is net of the effect of fellow group member contributions. Indeed, since under that treatment, contributions to the local goods are higher, we could expect more votes for secessions if subjects choose the public goods to which others contribute the most. However, net of that effect, we still find that decentralisation reduces the likelihood that subjects vote for secession. Therefore, even under the relatively simplistic institutions imposed by the restrictions of the laboratory, subjects choose to secede less often when they are allowed to interact with a smaller group for a larger number of public goods in the experiment. This effect might be capturing how decentralisation diminishes the effects of grievances from local group members towards the members of the larger group.

Third, we do not find any effect from the Identity treatment, in which we reinforced the saliency of the local group identity. This result is in contradiction with our initial hypotheses. Moreover, the Identity treatment has no impact on the effect of the Decentralisation treatment; the interaction effects are insignificant.

However, it is worth noting that by not including any data from the sessions in which local identity was reinforced, our results on the Decentralisation treatment would be much weaker, or even disappear. Therefore, we believe that local identity might play a role that we were not able to uncover in our data.

One shortcoming of our Identity treatment is how local group identities were reinforced symmetrically. Indeed, the treatment was the same for each local group in the session. This might translate real-world settings such as ex-Yugoslavia, the Soviet Union, or Belgium, for example, where there is a mosaic of different ethnic groups. However, secessionist movements frequently appear where one relatively small group is against the remainder of the national community, such as in Canada, Spain, or the United Kingdom,[10] for example. It might be interesting, then, to consider an experiment where we strongly reinforce local identity in one of the local groups, but not in the others.

We are aware that the experimental design reported here is a simplification of real-world separatist movements. Nevertheless, we believe that it captures some features of these movements and decentralisation. First, local groups and public goods capture how supplying public goods closer to the contributing voters (subjects) increases the confidence of voters that their interests are better represented. This, however, comes at the cost of efficiency, since global public goods can benefit from economies of scale. Second, the reinforcement of local identities capture the importance of ethnic and minority identities in secessionist movements. Future re-

[10] Note, however, that the United Kingdom was composed of several regions with specific identities and secessionist groups in the past. Indeed, Ireland achieved independence in 1921.

search extensions could consider enriching the experimental design by, for instance, introducing regional disparities in endowment to simulate the presence of natural resources or differences in income distributions. Future research could also consider refinements on the institutions, by using mechanisms other than voluntary contributions, for example.

Appendix

4.A Instructions (translated from French)

The following instructions are for the Baseline treatment. We add the instructions that are specific to the Decentralization and Identity treatments in italics into brackets. The instructions for the sessions where we control for the order effect are identical to these instructions we only invert part 1 and part 2. The questionnaire used to form the groups in the Identity treatment is presented at the end of the instructions.

General information

We thank you for participating in this experiment in economics. Your payoffs depend on your decisions. It is therefore important that you read the following instructions carefully.

Instructions are distributed for your personal use. We thank you for not communicating with other participants during the experiment.

During the experiment, we will not talk about Euros but about ECU (Experimental Currency Units). All payoffs will be calculated in ECU. At the end of the experiment, the total number of ECU that you earned will be converted into Euros at the following conversion rate:

100 ECU = 0.45 Euro

In addition to this amount, you will receive a show up fee of 5 Euros. All payments will be made in private and in cash in a separate room. Other participants will never know the amount of your payoffs in this experiment.

Groups' formation

Before the start of the first part, the computer program will form randomly groups composed of 9 people. Each group of 9 people is composed of three sub-groups of 3 people.

A group of 9 people is called "global group" and a sub-group of 3 people a "local group". A global group thus comprises three local groups, A, B and C.

[Additional instructions for the Identity treatment:

Each local group of 3 people within a global group is formed according to the proximity of the answers given in a questionnaire that will appear on your screen. The questionnaire consists of four proposals. For each of them, we ask you to tell if you:

- Strongly disagree
- Disagree
- Agree
- Strongly agree

Once the questionnaire is completed by each participant the computer program will use an algorithm to form the local groups according to the proximity of the answers given to these different proposals.

Thus, you will be paired in your local group with two other people in the overall group of 9 that expressed the nearest opinion to yours. You will not know at any time the detailed answers of the other participants; likewise, no one will know the details of your answers.

The two other local groups are composed of participants whose views are less similar to yours but the name of the local group (A, B, C) is independent of the distance with the opinions of your local group (for example, if you are in Group A, the members of group C are not necessarily further from your opinions than the members of group B).

To sum up, each group of 9 people is composed of three sub-groups of 3 people. Groups of 9 people are randomly formed while the sub-groups of 3 are formed using the algorithm. *]*

Thus, you will be at the same time a member of a local group with 2 other people and a member of a global group that includes your local group and the 6 members of the two other local groups.

The following table illustrates the composition of a global group and its local groups.

Global group	Local group A	Local group B	Local group C
participant 1 participant 2 participant 3	participant 1 participant 2 participant 3		
participant 4 participant 5 participant 6		participant 4 participant 5 participant 6	
participant 7 participant 8 participant 9			participant 7 participant 8 participant 9

For example, one participant is a member of both the global group and the local group A.

The composition of each group will remain the same throughout the experiment. You will remain paired with the same co-participants in your local group and in your global group in all parts of the experiment. You will never know the identity of your co-participants and your co-participants will never know your identity. All decisions are anonymous.

Part 1

The first part consists of 12 periods during which you may allocate ECU between multiple accounts. Your payoff in this section is the sum of your earnings in each period.

Description of each period

At the beginning of each period, each participant receives 60 ECU. We call this sum the "endowment". You have to decide how to allocate this endowment between your private account and several public accounts.

You have the choice to allocate the ECU in three public accounts: **two global public accounts and one local public account**. *[This sentence is replaced by the following in the Decentralization treatment:* You have the choice to allocate the ECU in three public accounts: **one global public account and two local public accounts**.*]*

- The 9 members of the global group may allocate ECU to the global public account G1 and to the global public account G2. The amount of a global public account is the sum of the ECU allocated by you and the other 8 members of the global group to this account.
- Only the 3 members of your local group may allocate ECU to your local public account. The amount of your local public account is the sum of the ECU allocated by you and the two other members of your local group to this account.

Members of the two other local groups to which you do not belong also have their own local public account. The local group A can allocate ECU to the local public account A, the local group B may allocate ECU to the local public account B, and the local group C may allocate ECU to the local public account C.

Thus, you have to decide how much of your 60 ECU you keep on your private account and how much ECU you allocate to:

- The global public account G1 (between 0 and 60 ECU)

- The global public account G2 (between 0 and 60 ECU) *[In the Decentralization treatment this is replaced by:* Your local public account (A, B or C) (between 0 and 60 ECU).*]*

- Your local public account (A, B or C) (between 0 and 60 ECU).

You must enter a value in each box on your screen. The difference between your endowment 60 ECU and the sum of ECU allocated to each public account remains on your private account. The sum of your ECU allocated to these accounts, public and private, may not exceed 60 ECU.

You will make your decisions as in the screen shown in Figure 1. The consequences of your decisions are explained in detail on the next page.

Figure 1. Example of a decision screen

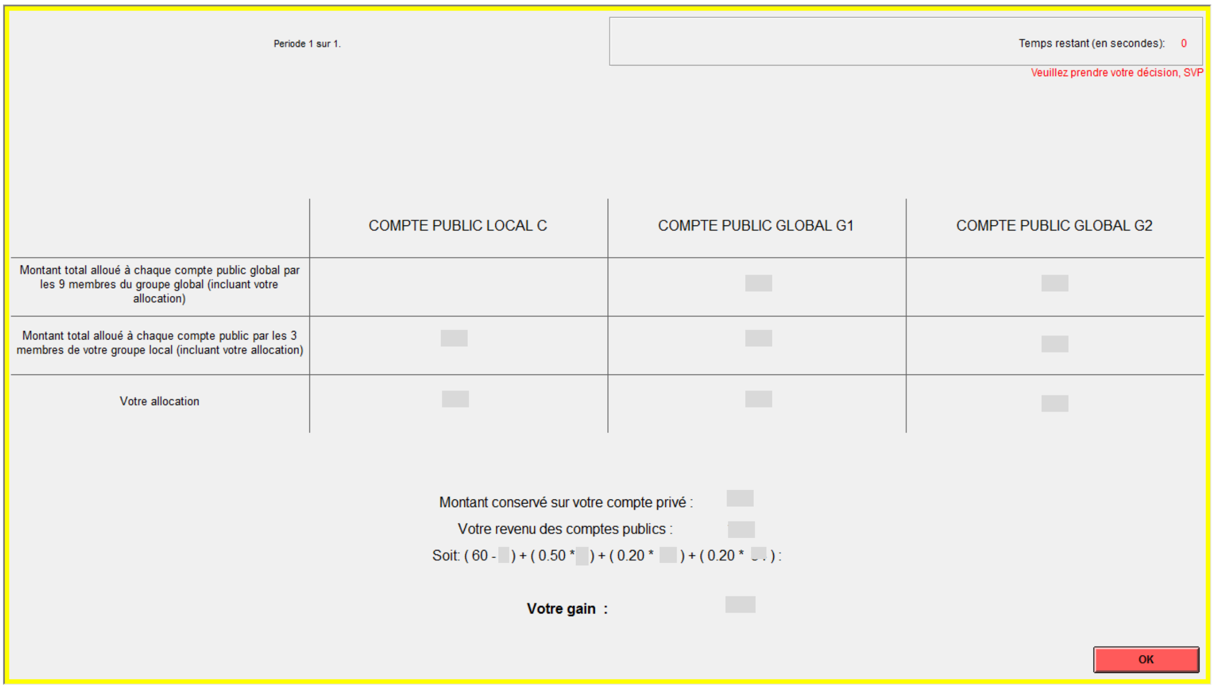
Once all group members have decided the amount they allocate to the three public accounts, you are informed of:

- The total amount allocated to each global public accounts by the 9 members of the global group (including your allocation) *[In the Decentralization treatment this is replaced by:* The total amount allocated to the global public account by the 9 members of the global group (including your allocation).*]*
- The total amount allocated to each global public accounts by the 3 members of your local group (including your allocation) *[In the Decentralization treatment this is replaced by:* The total amount allocated to the global public account by the 3 members of your local group.*]*
- The total amount allocated to your local public account by the 3 members of your local group (including your allocation). *[In the Decentralization treatment this is replaced by:* The total amount allocated to your local public accounts by the 3 members of your local group (including your allocation).*]*

Your screen will also remind you the amount of your allocation to the global public accounts and the local public account and the amount held on your private account. *[This sentence is replaced by the following in the Decentralization treatment:* Your screen will also remind you the amount of your allocation to the global public account and to the local public accounts and the amount held on your private account.*]* It also shows your gain in that period. You are not informed of the amounts allocated to local public accounts by the two other local groups.

Figure 2 reproduces the feedback screen at the end of a period.

Figure 2. Example of the feedback screen displayed at the end of a period.



Calculation of your payoff

The revenue drawn from a public account is different depending on whether it is a global public account or a local public account:

- The revenue drawn from each global public account represents 20% of the sum of the 9 individual allocations to this global public account, *[This sentence is replaced by the following in the Decentralization treatment:* The revenue drawn from the global public account represents 20% of the sum of the 9 individual allocations to the global public account, *]*
- The revenue drawn from the local public account represents 50% of the sum of the three individual allocations to the local public account. *[This sentence is replaced by the following in the Decentralization treatment:* The revenue drawn from each local public account represents 50% of the sum of the three individual allocations to this local public account.*]*

Your payoff at each period is calculated using the following formula (if you have difficulty understanding these formulas do not hesitate to ask questions):

Payoff in a period	=	Your endowment in ECU
		- Your allocation to the two global public accounts and the local public account
		+ 20 % of the total number of ECU allocated to the global public account G1
		+ 20 % of the total number of ECU allocated to the global public account G2 *[In the Decentralization treatment this sentence is replaced by:*
		+ 50% of the total number of ECU allocated to your local public account (A, B or C)*]*
		+ 50% of the total number of ECU allocated to your local public account (A, B or C)

This formula shows that your payoff at the end of a period consists of two parts:

1) of the ECU that you have kept for yourself (namely your endowment - your allocation to the public accounts)
2) of the sum of the total revenues from both global public accounts and your local public account. *[This sentence is replaced by the following in the Decentralization treatment:* of the sum of the total revenues from the global public account and your both local public accounts.*]*

Here are some examples.

Example 1
Suppose that the sum of the allocations of the 3 members of a local group to their local public account is 90 ECU. Suppose also that the sum of the allocations of the 9 members of the global group is 70 ECU to the global public account 1 and 300 ECU to the global public account 2. In this case, the revenue from public accounts is:
50% (90) + 20% (70) + 20% (300) = 45 + 14 + 60 = 119 ECU
[This example is replaced by the following in the Decentralization treatment: Suppose that the sum of the allocations of the 3 members of a local group is 90 ECU to their local public account 1 and 70 ECU to their local public account 2. Suppose also that the sum of the allocations of the 9 members of the global group is 300 ECU to the global public account. In this case, the revenue from public accounts is:
50% (90) + 50% (70) + 20% (300) = 45 + 35 + 60 = 140 ECU]

Example 2
Suppose that the sum of the allocations of the 3 members of a local group to their local public account is 60 ECU. Suppose also that the sum of the allocations of the 9 members of the global group is 90 ECU to the global public account 1 and 50 ECU to the global public account 2. In this case, the revenue from public accounts is:
50% (60) + 20% (90) + 20% (50) = 30 + 18 + 10 = 58 ECU.
[This example is replaced by the following in the Decentralization treatment: Suppose that the sum of the allocations of the 3 members of a local group is 60 ECU to their local public account 1 and 90 ECU to their local public account 2. Suppose also that the sum

of the allocations of the 9 members of the global group is 50 ECU to the global public account. In this case, the revenue from public accounts is:
50% (60) + 50% (90) + 20% (50) = 30 + 45 + 10 = 85 ECU.]

You always have the option to keep the ECU on your private account or to allocate them to a public account. Each ECU you keep on your private account increases your payoff in the current period by 1 ECU.

If you allocate 1 ECU to a public account, the total allocation of this public account increases by 1 ECU. In this case, your revenue increases by 50% × 1 = 0.5 ECU if it is a local public account and 20% × 1 = 0.2 ECU if it is a global public account. Your allocation to a public account also increases the revenue of other members:

- If it is a local public account, the revenue of the two other members of your local group will also be increased by 0.5 ECU each. So, the total revenue of your local group from your local public account will be increased by 3 × 0.5 = 1.5 ECU.
- If it is a global public account, the revenue of the eight other members of the global group will also be increased by 0.2 ECU each. So, the total revenue of the global group from the global public account is increased by 9 × 0.2 = 1.8 ECU.

Similarly, your income increases for each ECU allocated to a global public account by the other members of the group and for each ECU allocated to your local public account by the other members of your local group. For each ECU allocated by another member of your local group or global group, you win 0.5 and 0.2 ECU respectively. However, your income is not affected by the ECU allocated by members of other local groups to their local public account.

To sum up:

- You receive an endowment.
- You decide of your allocation to two global public accounts and one local public account. *[This sentence is replaced by the following in the Decentralization treatment:* You decide of your allocation to one global public account and two local public accounts.*]*
- You are informed of the amount of allocation to each global public account and local public account associated with your local group and your payoff. *[This sentence is replaced by the following in the Decentralization treatment:* You are informed of the amount of allocation to the global public account and to each local public account associated with your local group and your payoff.*]*

At the end of each period, a new period starts automatically. You receive a new endowment 60 ECU.

* * *

Please read again these instructions. If you have any question, raise your hand and we will answer to your questions in private. Thank you to fill out the understanding questionnaire that has been distributed. We will come to you to check your answers in private.

Part 2

(*distributed after completion of Part 1 and the questionnaire*)

The second part consists of 12 periods. Your payoff in this section is the sum of your earnings in each period. The composition of your local group and your global group is the same as in the previous part, but in this part you will only interact with the other two members of your local group.

Description of each period

The second part is similar to the first part: at the beginning of each period, each participant receives 60 ECU and has to decide how to allocate this endowment between his private account and three public accounts.

The only difference with the previous part is that the three public accounts are now **three local public accounts**.

Only three members of your local group may allocate ECU to your local public accounts. The amount of the local public accounts is the sum of the ECU allocated by you and the two other members of your local group to these accounts.

Members of the two other local groups to which you do not belong also have their own local public accounts. The local group A may allocate ECU to the local public accounts A1, A2 and A3; the local group B may allocate ECU to the local public accounts B1, B2 and B3; and the local group C may allocate ECU to the local public accounts C1, C2 and C3.

Thus, you need to decide how much of your 60 ECU you keep on your private account and how much you allocate to:
- Your local public account 1 (A, B or C) (between 0 and 60 ECU)
- Your local public account 2 (A, B or C) (between 0 and 60 ECU)
- Your local public account 3 (A, B or C) (between 0 and 60 ECU)

You must enter a value in each box displayed on your screen. The difference between your endowment 60 and the sum of the ECU allocated to each public account remains on your private account. The sum of all your ECU allocated to these accounts, public and private, may not exceed 60 ECU.

Once all group members have decided the amount they allocate to these three public accounts, you are informed of the total amount allocated to each of the three local public accounts by the 3 members of your local group (including your allocation).
Your screen will also remind you the amount of your allocation to each local public account and the amount held on your private account. It also shows your payoff in that period. You are not informed of the amounts allocated to local public accounts by the two other local groups.

Calculation of your payoff

The revenue drawn from each local public account represents 50% of the sum of the 3 individual allocations to this local public account.

Your payoff at each period is calculated using the following formula:

Payoff in a period	=	Your endowment in ECU
		- Your allocation to the three local public accounts
		+ 50% of the total number of ECU allocated to your local public account (A, B or C)
		+ 50% of the total number of ECU allocated to your local public account (A, B or C)
		+ 50% of the total number of ECU allocated to your local public account (A, B or C)

This formula shows that your payoff at the end of a period consists of two parts:

1) of the ECU that you have kept for yourself (namely your endowment - your allocation to the public accounts)
2) of the sum of the total revenues from your local public accounts.

As previously, each ECU you keep on your private account increases your earning in the current period by 1 ECU. If you allocate 1 ECU to a local public account, the total allocation of this public account increases by 1 ECU. In this case, your revenue increases by 50% × 1 = 0.5 ECU. The revenue of two other members of your local group will also be increased by 0.5 ECU each. Thus, the total revenue of the local group from the local public account will be increased by 3 × 0.5 = 1.5 ECU.

Similarly, your income increases by 0.5 ECU for each ECU allocated to a local public account by other members of your local group. However, your income is not affected by the ECU allocated by members of other local groups to their local public accounts.

At the end of each period, a new period starts automatically. You will receive a new endowment of 60 ECU.

* * *

Please read again these instructions. If you have any question, raise your hand and we will answer to your questions in private.

Part 3

(*distributed after completion of Part 2*)

The third part consists of 12 periods. Your payoff in this section is the sum of your earnings in each period. The composition of your local group and your global group is the same as in the previous parts.

Choice of the available public accounts

Before the start of the first period, you have to vote to select the nature of the public accounts that will be available for the next 12 periods. You will vote only once in this part.

You can choose between two options:

- An option with a local public account and two global public accounts (as in part 1) *[This sentence is replaced by the following in the Decentralization treatment:* An option with two local public accounts and one global public account (as in part 1).*]*
- An option with three local public accounts (as in Part 2).

If the option with a local public account and two global public accounts is selected *[This sentence is replaced by the following in the Decentralization treatment:* **If the option with two local public accounts and one global public account is selected***]*, you will interact at the same time with the 2 other members of your local group and with the members of the other two local groups (i.e. with 8 other people).

If the option with three local public accounts is selected, you will only interact with the two other members of your local group.

Once all the members have voted, the computer program calculates the majority choice in each of the three local groups. The option that will be applied to the next 12 periods of the game is the one that was chosen by a **majority of three local groups** within your global group of 9 people.

Before the start of the first period, you are informed of the outcome of the vote in your local group and of the majority choice in the global group. You are not informed about the details of the votes in your local group nor in other groups.

<u>Description of each period</u>

You receive 60 ECU at the beginning of the period. According to the majority vote, you can allocate the ECU of your endowment either between your private account, a local public account and two global public accounts (according to the rules of Part 1) *[This sentence is replaced by the following in the Decentralization treatment:* you can allocate the ECU of your endowment either between your private account, two local public accounts and one global public account (according to the rules of Part 1)*]* or between your private account and three local public accounts (according to the rules of Part 2).

* * *

Please read again these instructions. If you have any question, raise your hand and we will answer to your questions in private.

Questionnaire for the groups' formation

Please read each statement very carefully and evaluate how much you agree or disagree with each one of them.

For each statement, give your answer by checking the box that best describes your opinion.

You can only choose one answer from the following options:

1. Strongly disagree;
2. Disagree;
3. Agreement;
4. Strongly agree.

Statement 1: I enjoy visiting museums of contemporary art.
Statement 2: Surrogate motherhood should be authorized.
Statement 3: I am willing to consume genetically modified food.
Statement 4: I love practicing sports.

The rest of the instructions is similar to the other treatments.

Conclusion

This thesis investigated two issues pertaining to fiscal decentralisation: fiscal competition, and the choice of jurisdiction borders. The first two chapters studied a specific type of fiscal competition: bidding wars between regional governments to attract new investment from firms. Moreover, they analysed how these bidding wars affect the firm's structure, thus putting the spotlight on the strategic choices of the firm, and not only of governments. The last two chapters analysed the decision of voters to secede from a larger jurisdiction, first empirically and then using experimental methods.

Chapter 1 studied the strategic choice by a firm of how to allocate her production across multiple sites when these plants are allocated through a bidding war between many regional governments. We build a model in which the firm chooses how much to invest in each establishment, and then uses a multi-unit auction to "sell" them to regional governments. The latter have private benefits from hosting the firm on their territory, which are private information.

The main results of Chapter 1 are as follows. First, I find that equilibrium subsidies will depend on the firm's choice of capital amounts to invest. In particular, when she chooses asymmetric plants, she is able to increase her total subsidies. This increase is due to the inframarginal competition between the last two regions remaining in the bidding war. Second, I show that this bidding behaviour affects the optimal amounts of investment of the firm. More specifically, I find that she always chooses to differentiate her establishments. Therefore, the firm can strategically modify her allocation of investment across many plants to benefits from larger subsidies.

I then compare this result to a situation without a bidding war, in which the firm simply chooses two locations for the plants randomly. I find that under some conditions on the production function of the firm, total investment and total subsidies are always higher under a bidding war.

From a normative point of view, we describe the optimal mechanism to maximise the firm's total profits. We find that this optimal mechanism, defined by an allocation and a payment rules, can be implemented by the open ascending auction. Moreover, we find that this mechanism is socially efficient, as an uninformed social planner would choose identical allocation and payment rules. Finally, we solve for a more general optimal mechanism, in which the firm does not commit to investment amount before the auction takes place. We find that in expected value, the solution to this problem is identical to the one in the restricted model, with commitment.

The model in Chapter 2 departs from the one in the first chapter by considering an additional trade-off not present in the first chapter, or in the previous literature. In particular, we explore how the requirement for regions to make investment in public infrastructure before participating in the bidding war can reduce the incentive for the firm to differentiate the two plants. The argument is the following. When allocation plants through a bidding war, the firm differentiates her establishments, thus concentrating more production in one plant. In turn, this concentration increases the size of one plant, and thus the infrastructure needed to host it. Consequently, some regions decide not to invest in the necessary infrastructure, and do not take part in the bidding war. Finally, this reduced competition for the firm's investment potentially reduces the subsidies.

The main results of Chapter 2 are as follows. First, I show that by choosing to concentrate a large share of investment in one plant, the firm risks driving all regions out of the bidding war. Indeed, since the infrastructure cost is sunk and paid even when they lose the bidding war, when it is too large, many regions are better off only participating in the bidding for the small establishment. Second, I show that this feature of the competition has implications on the firm's choice of differentiation. Indeed, when entry costs are important enough, even a firm that would usually be better off concentrating all production in a single plant would choose to split in two establishments. More generally, these infrastructure costs moderate the tendency of the firm to put more production in one of the establishments, thus moving closer to identical plants.

Overall, the conclusions of the first two chapters are especially relevant in a world experiencing a trend of increased decentralisation. Indeed, both OECD and developing countries are seeing an increase in the number of sub-national jurisdictions. As highlighted in the thesis, this increase in the number of governments could amplify fiscal competition at the local level. Bidding wars for firms are an important source of fiscal competition between local governments, as illustrated by the amount of fiscal incentives granted to firms every year in the United States.

Furthermore, since these bidding wars are often for investments by multi-establishment firms, it is important to understand whether such firms can act strategically and allocate investment across sites in a way that increases total subsidies. The main implication of the first two chapters in this thesis is that indeed, firms can manipulate the bidding wars to increase subsidies. However, I also show that even with this distortion, it is usually still better, from a social welfare point of view, to allow these bidding wars since they allow the regions who value the firm the most to host the plants.

The last two chapters study the voters' endogenous decision of jurisdiction borders. In Chapter 3, I explore this question at a local level, reflecting the trend in which central governments, in recent decades, have modified borders of municipalities, promising cost savings and higher efficiency. Examples include municipal mergers in Finland, Japan, and Canada, as well as the push towards more collaboration amongst French municipalities. I use data from a specific example, in the Canadian province of Quebec, where voters were given the opportunity to vote whether they approved or opposed municipal mergers that were imposed a few years before by the central government. This particular event provides an original and unique dataset of public consultations on secessions in 213 municipalities, which I combine with a rich dataset on socio-economic characteristics for every municipality from the Canadian Census.

The main objective of Chapter 3 is to understand the motivations behind the opposition to municipal mergers. The economic literature on endogenous borders often emphasises a trade-off between economies of scale and heterogeneity of preferences (see, e.g., Alesina and Spolaore, 1997). Larger jurisdictions can more efficiently provide public goods, but there might be a better match between the preferences of voters and the public good in smaller jurisdictions. Alesina, Baqir, and Hoxby (2004) put forth another reason for the disapproval of large jurisdictions by voters: voters inherently dislike living in a jurisdiction with people different from them. Chapter 3 suggests that these two explanations are relevant in the voters' disapproval of large jurisdictions.

The main results are as follows. First, differences in income and language between a town and the other towns in the merger are important drivers of the secession decision. Second, while greater income differences does lead to more secessions, I find that this effect is not identical at different levels of language differences. In particular, when voters are mixed mostly with others of the same ethnic group (i.e., low language differences), they tolerate differences in income: income differences have no, or only a small effect on the probability of a secession. However, when the language differences are larger, differences in income greatly affect the probability of a secession. These results suggest that when deciding to secede, voters do not only care about the match between their preferences for the public goods and the public goods provided, but also directly care about the ethnic identity of the voters in their jurisdiction. In other words, voters prefer ethnically homogeneous municipalities.

In conclusion, Chapter 3 shows that ethnic identities do matter in the voters' decision to secede. While Chapter 3 considers linguistic groups, since they are important in Quebec's context, different dimensions of identities could matter in other regions. In particular, identity questions could be of importance to explain the secessionist movements in Scotland and Catalonia. More concretely, another lesson of Chapter 3 is that if governments care about the potential long-term benefits of ethnic diversity in local jurisdictions (as suggested by Putnam (2007) and Ottaviano and Peri (2005)), they should impose mergers and commit to a policy of not allowing further changes.

Chapter 4 approaches the question of endogenous borders from a more national point of view. The main objective of Chapter 4 is to investigate, using experimental methods, the link between decentralisation and secessionist groups. When central governments are confronted with a secessionist threat in one or more regions, they might devolve some power or competences to the regional entity, in the hope that the decentralization of power will accommodate regional demands and thereby quell the separatist movement. However, while decentralisation might allow an overall mix of public goods closer to the voters' preferences, it might also provide more resources to the secessionist movement, thus making them more organised and possibly stronger.

Given the difficulty to find causal estimates with observed data, Chapter 4 instead approaches the question with experimental methods. Briefly, our experiment consists of multiple public goods at two different levels: local and global. Each subject is part of one local group (with two other subjects), and of a global group (composed of three local groups). The experiment considers two dimensions of treatment: decentralisation and local identity. First, for the decentralisation dimension, we vary the number of each type of public goods. In the Centralisation treatments, subjects are faced with two global public goods and one local public good, while in the Decentralisation treatments they are faced with the opposite: one global public good and two local public goods. Second, for the identity dimension, we reinforce local identities in half of the sessions.

The results of Chapter 4 concern both the results of the vote and the level of contributions by subjects. First, it finds that the Decentralization treatment strongly decreases the probability that subjects vote for secession, although reinforced local identities have no effect on the votes. Second, the results also show that the Decentralization treatment increases contributions to the local public goods. However, the Identity treatment does not affect the level of individual contributions. To conclude, the results suggest that central governments could actually weaken secessionist movements by devolving some responsibilities to regional governments.

This question has had a relatively high profile in recent years at a national level, especially following the vote of the United Kingdom to leave the European Union, but also due to the debates in Scotland and Catalonia, for example. While the implementation of decentralisation in this experiment is obviously very simplified, it does capture some of the real-world features of decentralisation (e.g., less free-riding in local groups, more efficiency in global goods). Moreover, the second treatment dimension is related to the the findings of Chapter 3 on the link between ethnic identity and the probability of a secession. Given the importance of ethnicity in many secessionist movements around the world, the experiment introduces the same concept to investigate whether the creation of a local shared identity modifies the outcome of the vote, and whether it modifies the effect of the Decentralisation treatment. Indeed, in the real world, decentralisation might be more or less efficient at stopping secessionist movements depending on the strength of the ethnic identity of the region (as argued by Ezgi, 2009). While we do not find any effect of reinforced identity, future research should consider better ways to implement this treatment, such as creating local identities of asymmetrical strengths.

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