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Three Essays in Competition Policy

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Summary - Resumen

The three chapters of this thesis investigate different topics in competition policy. The first chapter empirically analyzes the consequences of the subsidies that were granted to some coalfields during the first years of the European Coal and Steel Community (1954-1962). I show that subsidies granted to the less efficient coalfields did not affect investment and thus failed in increasing productivity. The second chapter theoretically shows that an incumbent may implement loyalty rebates in order to prevent an efficient rival from entering the market. Finally, the third chapter analyzes both theoretically and empirically how the dynamics of a two-sided market affect the structure of the vertical relationships between a producer and a platform. The type of vertical relationship depends on the attractiveness of the brand sold and the size of the platform's installed base of customers. Depriving the platform of some present sales may prevent it from choosing its favorite type of contractual vertical relationship for future sales.

Los tres capítulos de esta tesis doctoral investigan aspectos de la economía de la competencia. El primer capítulo analiza los efectos de las ayudas financieras dirigidas a algunas minas durante los primeros años de la Comunidad Europea del Carbón y del Acero (1954-1962). Se muestra que estas

ayudas financieras no afectaron las inversiones de las minas y no permitieron el crecimiento de la productividad. El segundo capítulo demuestra teoréticamente que una empresa dominante puede ofrecer descuentos de fidelidad para impedir la entrada en el mercado de una empresa más eficiente. El tercer capítulo analiza teorética y empíricamente como la dinámica de un mercado "bilateral" afecta a las relaciones verticales entre un productor y la plataforma. El tipo de relación vertical depende de la atractividad de la marca del productor y de la base de clientela de la plataforma. La privación de algunas ventas en la plataforma puede impedir que la plataforma elija su tipo de relación preferido en el futuro.

CONTENTS

INTRODUCTION

This doctoral thesis consists in three independent chapters that investigate different aspects of the economics of competition policy. The role of economic analysis in competition policy has become increasingly important, both in practice and from a theoretical perspective. In particular, economists are particularly active in two important antitrust debates, which influence the way competition policy is implemented in practice.

The first debate, which has been fuelled by the Chicago School critique, is at the core of competition policy, as it questions its economic efficiency. The first two chapter of this thesis provide new insights into this debate, by analyzing the efficiency of two different aspects of competition policy. The first chapter of the thesis, entitled "Do taxes and Subsidies deter productivity? Evidence from the European Coal and Steel Community, 1954-1962," takes an historic approach to study the impact of State Aids, which are often used by policymakers, and yet understudied in the academic literature. The second chapter of the thesis, "Repeated Purchases, Loyalty Rebates, and Demand Foreclosure," focuses on exclusionary practices, and proposes a new model to explain how a dominant firm can implement a loyalty rebate scheme that prevent an efficient rival from entering the market. Such practices indeed justify policy action against dominant firms.

The third chapter, entitled "Two-sided Market Dynamics: Theory and Ev-

idence," is related to a second, more recent debate, which focuses on multi-sided markets. Nowadays, many commercial interactions are operated through such markets, where a platform sells to several distinct groups of users that may affect each other's utility. Such markets are characterized by externalities between the various sides of the market, which significantly affect their functioning and their dynamics. The characteristics of such markets raise the question of the efficiency of competition policy, as it is currently implemented. Indeed, experts generally argue that some practices that are generally considered anticompetitive, such as below-cost pricing, result from the normal competitive behavior in industries where there exist externalities between different sides of the market. The dynamic model developed in this chapter shows that exclusive dealing may have significant deterrent effects in such markets.

In the remainder of this introduction, I present these three contributions to the economics of competition policy in more detail.

Chapter 1: Do taxes and Subsidies deter productivity? Evidence from the European Coal and Steel Community, 1954-1962

In this first chapter, I exploit the creation of the first European Common Market as a quasi-natural experiment to investigate the effects of taxes and subsidies on firms' productivity. During the first years of the European Coal and Steel Community, from 1954 to 1958, national and supranational subsidies were granted to the less efficient coalfields in order to make them integrate the common market, while more productive coalfields were taxed. Using hand-collected data on coalfield productivity in Europe and the UK, I implement a

difference-in-difference method and find robust evidence that the end of this period significantly increased coalfields' productivity. I also investigate how coalfields' rationalization and investment decisions were affected by taxes and subsidies. My results suggest that taxes have a deterrent effect both on investment and productivity, while subsidies seem to fail both to significantly increase investment and to enhance productivity.

Chapter 2: Repeated Purchases, Loyalty Rebates, and Demand Foreclosure

In this chapter, I show that, under demand heterogeneity, loyalty rebates are extremely effective entry-deterrent strategies because they allow the incumbent to set a high price for the sales of present units and to commit to a low price for future units, thereby depriving the entrant of the scale it needs. This issue is directly related to the critique of the Chicago School, which argue that a firm cannot extent its market power either to prevent an efficient rival from entering the market or to increase its profit on another connected market. This approach has subsequently been criticized and several papers have developed models showing that such practices may succeed in leveraging the dominant firm market power.

The pricing mechanism developed in this chapter adds to this literature, but diametrically differs from exclusionary contracts and pricing schemes proposed in previous papers. It consists in charging an aggressive first-period price to deter entry before enjoying a leveraged dominant position in subsequent periods. Moreover, in my model, there is no need for the incumbent to know *ex-ante* each customer's type to deter entry, as it can use optimal loyalty rebates to implement an incentive-compatible menu of prices. Furthermore,

rebates may induce some customers to purchase unneeded units from the incumbent, generating additional revenue that finances its exclusionary strategy. This contrasts with the existing literature on this topic that generally considers that such "buyer opportunism" does not exist at equilibrium.

Chapter 3: Two-sided Market Dynamics: Theory and Evidence[1]

This last chapter develops a dynamic model of two-sided markets based on an extensive dataset provided by an e-commerce platform that operates online private sales. The model analyzes precisely how customer-side externalities affect the development of the platform and in particular, how it changes its relationship with producers. In the model, the attractiveness of the product brand and the size of the customer base affect the bargaining power of the producer *vis-à-vis* the platform, thereby influencing the choice of the selling mode. Some sales are operated under the *reseller* mode where the platform purchases and re-sells the goods, choosing the final price. This contrasts with the *marketplace* selling mode, where the producer uses the platform to "advertise" the sale but controls the price charged to customers. The model shows that the platform may impose the marketplace mode when its bargaining power increases. The empirical analysis corroborates these findings. Finally, simulations of the dynamics of the model demonstrate that a rival may significantly alter the growth of the platform, by offering exclusive contracts to the producer. Preventing the platform from marketing a brand also affects its ability to choose its preferred selling mode in the future.

[1]This chapter is based on a paper co-written with Romain de Nijs.

Chapter 1

Do Taxes and Subsidies Deter Productivity? Evidence from the European Coal and Steel Community, 1954-1962

1.1 Introduction[1]

On April 18, 1951, France, West Germany, Italy, Belgium, Luxembourg and the Netherlands ratified the Treaty of Paris, which founded the European Coal and Steel Community (ECSC). The ECSC main economic objectives were "*to ensure supply to the common market,* [...] *to ensure the establishment of the lowest prices,* [and] *to encourage firms to develop their production potential*".[2] In other terms, the aim of the ECSC (through the action of the High Authority) was to create a competitive European market for coal and steel. Accordingly,

[1] I thank Gabrielle Fack, Philippe Février, Juan-José Ganuza, Massimo Motta, Helena Perrone, Anne Perrot, David Spector, Hans-Joachim Voth. The usual disclaimer applies.

[2] See Mioche (2002), p. 12.

the Treaty abolished custom barriers on February 1, 1952 for coal, and on May 1, 1953 for steel. However, during the first years of the Community, from 1954 to 1958, which are referred to as the "transition period," the High Authority of the ECSC subsidized the less efficient coal mines in order to "*avoid swift and dangerous changes in production*, [...] *to prepare them* [both] *to integrate the common market*,"[3] and to face fierce competition from the most efficient mines. To do so, the High Authority granted – and allowed National Governments to grant significant subsidies to the less efficient mines of the Community. In particular, the French government was allowed to provide some of the French coalfields with financial support. Furthermore, the High Authority implemented a "perequation system," which consisted in levying taxes from German and Dutch coal producers to support Belgian and Italian coal production. Such financial aids were designed in such a way that they allowed Belgian and French coal producers to match German and Dutch producers' prices in various geographic areas. The High Authority put a definitive end to this tax and subsidy system on February 9, 1958, precisely four years after it was implemented.

Providing firms or even an entire economic sector with financial support – whatever the form it may take, is a common, and probably the simplest, industrial policy. In the US, some important economic sectors (e.g., automobile, banking and agriculture) benefited from State or Federal subsidies. In the EU, State aids are also commonly granted to firms. From 2001 to 2013, 4.765 cases of State aids have been notified to the EU Directorate General for Competition (DG Comp), 3.122 to the DG Agriculture and 495 to the DG Maritime Affairs.[4] The aim of such an industrial policy is to allow the less efficient firms

[3] See the document entitled "L'application du Traité instituant la CECA au cours de la période transitoire," p. 23 – Historical Archives of the European Union.

[4] Source: European Commission. See http://ec.europa.eu/competition/state_aid/statistics/statistics_en.html.

to remain active on the market while giving them the opportunity to make the necessary investments to increase their productivity. However, such a policy also distorts competition. This explains why they are generally considered *per se* anti-competitive. On the one hand, some firms, amongst the less efficient, are provided with financial aid that allow them to resist fierce competition from the more efficient rivals. On the other hand, more productive firms are implicitly or explicitly taxed more heavily.

In this paper, I exploit the creation of the first European Common Market as a quasi-natural experiment to investigate the effects of financial aids on firms' productivity. More precisely, I first assess the global impact of the end of the transition period on coal mines' productivity. Second, I analyse separately the specific effects of the taxes levied and the subsidies granted in the context of the ECSC.

This paper is directly related to the literature, which is still little developed, on the effects of State aids. Most of the theoretical literature on State aids points out the necessity of control, especially to ensure that countries do not engage in a collectively wasteful "subsidy war,"[5] but does not analyze the consequences of national or supranational subsidies on firms' outcomes.[6] The empirical literature is very limited and finds mixed results. Criscuolo et al. (2012), study the EU funded "Regional Selective Assistance" program that provides firms with financial support in specific regions. They analyze the impact of subsidies on firms' employment and productivity of UK firms and instrument aid reception by the exogenous changes in EU rules for aid eligibility. They find a significant impact on employment for small firms, but no clear effect on productivity. Moreover it is not clear whether their results could extend to other types of State aids that are often targeted to large industrial

[5]Dewatripont et Seabright (2006).
[6]See Friederiszick et al. (2007) for a survey.

sectors.

The effect of taxes on firms' investment decisions has been much more extensively analyzed in the economic literature. Most studies focus on permanent changes in tax policy that affect the user cost of capital, such as changes in corporate tax rates or R&D tax incentives, and find that they have an effect on investment.[7] The effect on productivity, is however, very rarely assessed.

Finally, my paper is also related to a flourishing literature that aims at understanding the main drivers of firms' productivity. Most studies analyze the effects of a change in the competitive environment on productivity.[8] For instance, Bloom et al. (2008) study the impact of Chinese import competition on technology and employment in twelve European countries during the last decade. They conclude that Chinese import competition increases the IT intensity of surviving firms, while it decreases employment. Bustos (2011) draws similar conclusions from her analysis of the impact of MERCOSUR on Argentinean firms. She provides evidence that expanded trade opportunities induce firms to upgrade technology. Some papers exploit the creation of common markets as I do. For instance, Griffith et al. (2006) study the effects of the EU Single Market Programme (SMP), which consists in a large scale reform implemented by the members of the European Union to reduce internal non-tariff barriers to trade. This reform was undertaken across a large number of countries. The authors identify the impact of the SMP from other macroeconomic effects, by including countries that were not involved in SMP as a control group and use cross-industry variations. This estimation strategy allows them to show that the increase in competition had a positive impact on innovative activity.

[7] See Hasset et Hubbard (2002) for a review, and Djankov et al. (2010) or Bloom et al. (2002) for recent empirical analysis.

[8] For a comprehensive review of literature on the link between competition and productivity, see Holmes et Schmitz (2010).

This literature reveals the various difficulties raised when assessing the effect of taxes and subsidies on firms' productivity. In some cases, the changes induced by the policy may be endogenous and at least partly caused by firms' behaviors. Another problem may be faced when the well-identified change in policy affects a large number of more or less connected markets, creating general equilibrium effects. Finally, firms generally adapt many aspects of their production process and characteristics of their products in response to a change in the competitive environment (firms may change their locations or alter the main characteristics of their products in some ways that are difficult to predict or observe, and very likely to bias the result of the empirical analysis).[9] The specific case of the creation of the common market for coal and steel is of particular interest as it addresses in a satisfactory way these main challenges. The "transition period" is a well-identified and exogenous change in the competitive environment of the market for coal. The rules for the reception of taxes and subsidies were clearly stated in the Treaty, and the end of the perequation system was determined by the High Authority. Moreover, the policy only affected specific industrial sectors in specific countries. The focus on the coal sector allows me to measure very precisely the effect of the policy on investment and productivity in this industry. Coal quality is given by the geological characteristics of the mine, which are exogenous fixed parameters that cannot be adapted to the economic environment. After controlling for these characteristics, the evolution of mine productivity can be precisely measured and compared both across coalfields and over time. Furthermore, coalfields located in similar countries, such as the UK, which did not participate in the European Coal and steel Community, can be used as a control group.

In this paper, I first exploit the end of the "transition period" in a difference-

[9] See Vogel (2008).

in-difference analysis and find robust evidence that the end of the perequation system induced coalfields to significantly increase their productivity. Second, I specifically assess the effect of taxes and subsidies on firms' rationalization behavior and investment. One may expect taxes to deter investments, including *productive* investments that aim at fostering productivity. The magnitude of the effect is, however, an empirical question. The effect of subsidies on investment and productivity is theoretically ambiguous. Subsidies may increase investment, by lowering its cost. However, most of the subsidies are only given to less efficient firms, which may expect to loose this financial support if they increase their productivity. Subsidized firms may not have any interest in investing in the most efficient technologies in order to remain eligible for future financial support. The net impact of subsidies therefore needs to be estimated. I separately analyze the effects of taxes and subsidies and find that taxes have a both a deterrent effect on investment and productivity, while subsidies do not have any significant effect on productive investment expenditure, and fail to increase productivity.

This paper is organized as follows. In the next section, I describe the historical context and specify the various subsidies granted during the "transition period" in order to prepare less efficient firms to compete on the merits within a common market. Section 3 presents the data and descriptive statistics and section 4 details the empirical strategy. Section 5 presents the results and section 6 concludes.

1.2 Historical context

From February 7, 1954 to February 9, 1858, the High Authority of the ECSC implemented the measures it considered necessary for the creation of the com-

mon market and the progressive adaptation of production to the new conditions in which it took place. The main objective of this transition period was indeed to ensure that each active coalfield within the ECSC would be in a position to compete within a common market.

The High Authority of the ECSC either granted significant financial support to the less productive mines of the Community or authorized the State members to do the same. The High Authority established a perequation levy per ton of coal sold, which represented a uniform percentage of producers' average revenues, on the coal production of the countries where average costs were less than the weighted average of the Community. Belgian and Italian mines benefited from these subsidies, while German and Dutch mine producers were taxed to finance the aids. In addition, several coalfields also benefited from national governmental support.

More precisely, the Belgian mines, mostly located in the North (Campine area) and in the South (Bassin Sud) of the country, were provided with financial support from both the Belgian government and the ECSC, through the perequation system. Such subsidies aimed at lowering the price of Belgian coal to all consumers of such coal in the common market to the vicinity of the forecast costs of production of such coal at the end of the transition period, with a view to bringing it as close as possible to the common market price. The High Authority also granted an additional compensation for the exports of Belgian coal, which corresponded to 80 percent of the difference, determined by the High Authority, between the delivered price (F.O.B. plus transport) of Belgian coal and the delivered price of coal from other countries of the Community. Furthermore, the High Authority also imposed maximum price lists in well-defined geographical areas to ensure that the level of subsidies granted to the less efficient mines (in particular Belgian coalfields) were

adequate and allowed them to compete with the most efficient ones. Such price regulation was used to mitigate competition, especially between Belgian and German mines, in order to prepare the former to face fierce competition pressure from the latter. The High Authority put an end to this area prices in 1958, at the end of the transition period.

In Italy, mines located in La Thuile (in the Alps) as well as in Sulcis (in Sardinia) were also granted significant financial support.

In France, mines did not benefit from the perequation system of subsidy (as their costs were close to the weighted average production cost of the ECSC coalfields), but the High Authority authorized the French government to grant "limited" subsidies to French coalfields.[10] The subsidies provided to the French mines decreased during the transition period and finally came to an end in 1957.

Finally, French, Italian and Belgium coalfields benefited also from the perequation system as they were not taxed by the Authority. Such tax reductions can be interpreted as an aid as German and Dutch mines, which did not receive any subsidy during the transition period, did have to pay extra taxes. Table 1.1 displays the amount of taxes levied on German and Dutch mines, as well as the amount of subsidies granted to Belgian and Italian mines through the perequation system.

During these five years, the subsidy granted the Belgian mines through the perequation system amounted $50m, which corresponded to 8 percent of the value of the annual Belgian coal production. The financial advantage given to Belgian mines compared to German ones is therefore about $100m, which represented about 15 percent of the value of the annual Belgian coal produc-

[10]The Authority also allowed the French government to subsidize imports of coke (a specific type of coal) that can be used with coal produced in Saarland and in Lorraine (in the East of the country) in order to produce steel. In addition, the French government subsidized these two coalfields until 1955.

TABLEAU 1.1: The perequation system: subsidies and taxes (in $m)

	1952-1953	1953-1951	1954-1955	1955-1956	1956- 1957	1957-1958	Total
			I. Taxes				
German mines	2,932	13,880	14,483	10,980	7,601	2,645	52,521
Dutch mines	248	1,204	1,210	1,123	682	0	4,467
Total	3,180	15,084	15,693	12,103	8,283	2,645	56,988
			II. Subsidies				
Belgian mines	488	11,889	14,183	11,830	7,997	3,686	50,073
Italian mines	0	2,400	2,640	960	520	0	6,520
Total	488	14,289	16,823	12,790	8,517	3,686	56,593

SOURCES: *Haute Autorité, C.E.C.A Rapport Financier pour l'Année 1958, Annexes*

tion. These figures do not take into account the above-mentioned subsidies granted by the national governments. In addition to the subsidies distributed by the ECSC, the Belgian government paid about $90m to Belgian coal producers between 1953 and 1958, especially to help the coalfields located in Belgium's Borinage mining region. The State aids that the French government was allowed to distribute to French coal producers amounted to about $100m between 1953 and 1956.

The Treaty of Paris explicitly stipulated that the perequation system was to end in February 1958. However, it clearly appeared that the effectiveness of the subsidies granted to the Belgian mines was extremely limited. The Belgian State finally provided its less efficient mines with financial support even after the end of the transition period, with the consent of the High Authority. The High Authority accepted such additional financial support imposing some drastic conditions, including the closing of the less productive coal extraction sites. I analyze these post-1958 subsidies in order to disentangle the effects of taxes and subsidies on coal mines' productivity.

In the next sections, I therefore analyze not only the global impact of the end of the transition period on productivity in the coal industry, but I also assess more specifically the effect of the taxes and subsidies distributed by the ECSC and national governments.

1.3 Data and Descriptive statistics

1.3.1 Data

In order to measure productivity in the coal industry, I hand-collected weekly data for production and number of workers (as well as other variables as number of working days and absenteeism), for 18 coalfields in the Community, from January 1954 to January 1963 at the Historical Archives of the European Community. These very detailed data, which are referred to as *Statistiques hebdomadaires* (*Weekly Statistics*), come from the statistics division of the High Authority of the ECSC. This information is available for 18 coalfields in the ECSC, which are displayed on the map below (Figure 1.1).[11] I use this information to compute the productivity for each coalfield. It is defined as the ratio of its weekly production (in tons) to the weekly number of workers active in the corresponding mines. Productivity is thus expressed in ton per worker per week.

Other information regarding ECSC coalfields mainly comes from the *Rapports généraux sur l'activité de la Communauté* (General Reports of the activity of the High Authority),[12] which describe the political, social and economic situation of coal and steel industries in the ECSC. The statistics appendices of these reports provide annual figures regarding inter ECSC countries coal exchanges and import and export to countries outside the Community. These appendices also report the annual production of steel per region within the

[11] The coalfields for which the data are available are the following: Campine and Bassin Sud in Belgium; Aquitaine, Auvergne, Blanzy, Cévennes, Dauphiné, Loire, Lorraine, Nord Pas de Calais, and other mines (located in the West) in France; Aachen, Niedersachen and Ruhr in Germany; La Thuile and Sulcis in Italy and Limburg in the Netherlands. The last coalfield for which data are available is Saarland, a German region that was under French control from 1947 to 1957, even though the economic "reunification" with Germany dated July 7, 1959, when West Germany's Deutsche Mark became the official currency. In our analysis, we classify Saarland as a German mine.

[12] See the sources in Appendix.

ECSC, which, as further explained below, is used as proxy of the regional demand for coal. In addition, information contained in these reports allowed me to construct time series on the number of active sites and annual investment per site for each coalfield.[13] In order to construct the time series on taxes and subsidies from the perequation system and State Aids, I used the Financial Reports as well as the Official Journal of the ECSC.

Finally, I collected information regarding coalfields' production and number of workers in the UK, as a control group. This information comes from the *Colliery Year Book and Coal Trades Directory* published by the National Coal Board. Information is available for 8 coalfields in England, Wales and Scotland (See Figure 1.1).[14]

1.3.2 Descriptive statistics

This section describes the ECSC coalfields as well as intra-community coal exports. It also reports descriptive statistics on coal production and coalfield's productivity in ECSC countries as well in the UK.

ECSC coalfields' location The location of mines in the ECSC, as shown in Figure 1.1, is very concentrated in the "industrial triangle" as defined in the Schuman Plan (see Figure 1.2). This industrial triangle is a relatively small region in the middle of Western Europe, which was considered as the "industrial heart" of the European community. Indeed, Figure 1.2 shows that this area did not only concentrate coal production, but also steel centers, as steelworks

[13]The information on number of active sites and investment is available for regrouped categories of coalfields: Aachen, Niedersachsen and Saar in Germany, Campine and Bassin Sud in Belgium, Limburg in the Netherlands, Nord Pas-de-Calais, Lorraine, Centre-Midi and other mines in France, and all Italian mines together. Figures for the number of active sites are sometimes missing for specific years: I imputed it using a linear approximation.

[14]These coalfields are the following: Durham, East Midlands, North Western, Northern, Scotland, South Western, West Midlands and Yorkshire.

located in this region produced 81 percent of the total ECSC production in 1952.[15]

FIGURE 1.1: **Location of Coalfields in the ECSC and the UK**

NOTES: Coalfields have been geolocalized with Google Maps.

Intra-ECSC annual coal exports Figure 1.3 shows the evolution of annual coal exports from the various ECSC countries within the Community. It shows the relative economic power of each ECSC country in the market for coal. Germany is the largest exporting country, before France and Belgium. Interestingly, the evolution of intra-ECSC coal exports suggests that the national subsidies and, more globally, the perequation system (i.e., both taxes levied in Germany and in the Netherlands, and subsidies granted to Belgian and Italian mines) distorted intra-community trade. The share of intra-ECSC exports from Belgium and France decreased after the end of the transition period, while it increased for German and Dutch mines. This suggests the fact that the

[15]Calculations from the *Sixième rapport général, Annexe statistique*, C.E.C.A., 1958, tables 22 and 23 p. 371.

FIGURE 1.2: The ECSC and the industrial triangle

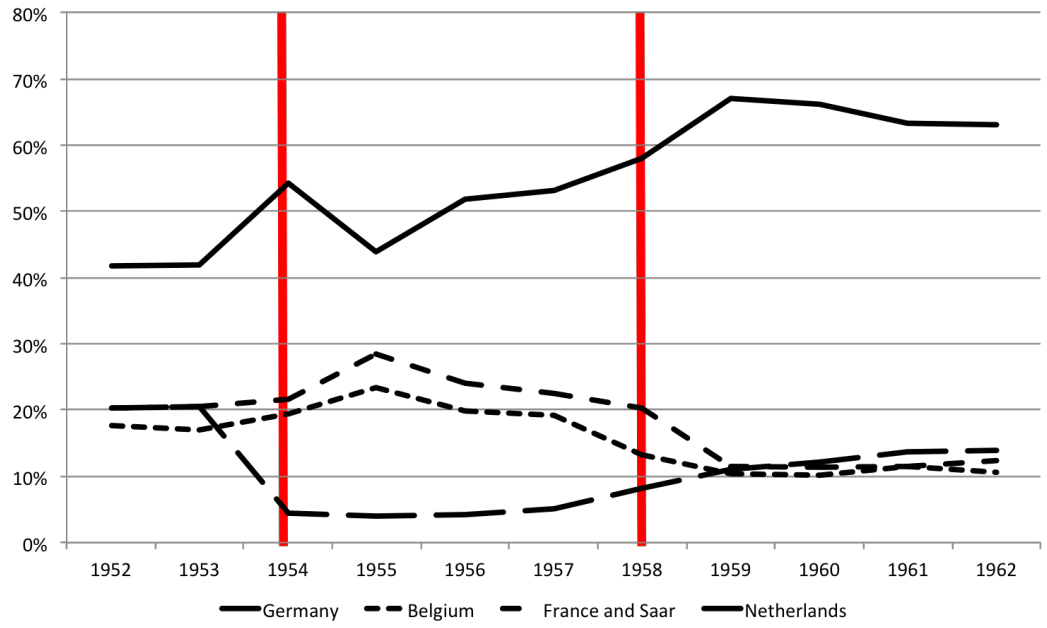
NOTES: Map illustrating the size of the coalfields and heavy industry regions in some of the Member States of the European Coal and Steel Community in March 1951.

SOURCES: The Schuman Plan. Keystone. Black and White.

implementation of the subsidy system affected the relative economic power of the main coalfields by increasing the weakest mines' exports and decreasing the exports of the strongest ones.

Coalfields' production and productivity Table 1.2 shows the evolution of the average weekly coal production and productivity at the country level: UK is the largest producer, followed by Germany, France, Belgium, The Netherlands and Italy. Tables 1.3 and 1.4, which report in greater details the average production and productivity by coalfield, confirm that the productive capacity of coalfields is very heterogeneous: the Ruhr coalfield in Germany accounts for almost half of the ECSC total production, whereas La Thuile and Sulcis in Italy account for respectively 0.03 percent and 0.4 percent of the ECSC production in 1954. France also has several very small coalfields that ac-

FIGURE 1.3: Evolution of relative intra-ECSC exports



NOTES: *Huitième rapport général*, C.E.C.A., 1960, *Annexe Statistique*, Table 7, 8 and 19 and *Douxième rapport général*, C.E.C.A., 1964, *Annexe Statistique*, Table 8, 9 and 11.

count each for less than 1 percent of the total ECSC production (Aquitaine, Auvergne, Dauphiné and Autres mines). Finally, the evolution of the average productivity shown in Table 1.2 suggests that ECSC countries experienced a quick increase in productivity after the end of the transition period. In the next section, I develop an empirical strategy to precisely estimate the impact of the end of the transition period, as well as the specific effect of taxes and subsidies on coal producers' investments and productivity.

TABLEAU 1.2: Evolution of coal production and productivity in ECSC and UK

	Average weekly coal production (tons)					
	Belgium	France	Germany	Italy	Netherlands	UK
1954	568,960	1,052,446	2,798,944	20,046	233,676	4,035,525
1955	578,775	1,058,591	2,834,238	21,195	228,764	3,968,454
1956	574,467	1,058,687	2,921,940	20,054	226,859	3,960,114
1957	562,362	1,092,854	2,895,716	18,766	217,890	3,964,862
1958	525,821	1,113,132	2,881,704	13,129	227,656	3,800,662
1959	446,771	1,124,520	2,730,591	13,709	227,538	3,685,283
1960	445,062	1,090,648	2,754,232	13,387	239,106	3,468,827
1961	433,211	1,009,379	2,732,596	14,057	241,102	3,397,731
1962	414,207	1,016,353	2,743,556	13,183	223,233	3,550,096

	Average weekly productivity (tons/worker)					
	Belgium	France	Germany	Italy	Netherlands	UK
1954	5.0	7.2	7.3	3.0	7.2	6.1
1955	5.2	7.4	7.5	3.8	7.1	6.0
1956	5.3	7.5	7.5	4.2	7.0	6.0
1957	5.7	7.7	7.5	4.2	7.0	6.0
1958	5.8	8.0	7.7	4.6	7.2	5.9
1959	6.1	8.3	8.6	5.2	7.6	6.0
1960	6.6	8.7	9.7	5.9	8.5	6.2
1961	7.2	9.1	10.4	6.7	9.5	6.5
1962	7.8	9.4	11.2	7.3	9.4	7.0

NOTES: Average productivity is computed by weighting each coalfield by its share in production. ECSC statistics are computed from the *Statistiques Hebdomadaires* published by the Statistics Division of the High Authority of the European Coal and Steel Community. UK Statistics are computed from the *Colliery Year Book and Coal Trades Directory* published by the National Coal Board.

1.4 Estimation Strategy

1.4.1 Estimating the effect of the end of transition period on firms' productivity

The difference in difference strategy I first analyze the global impact of the end of the transition period on coalfields' productivity using a difference

TABLEAU 1.3: Descriptive statistics of the ECSC coalfields (1954-1962)

	Average weekly production In tons	**Average weekly productivity** in tons per worker	**Share in ECSC production in 1954** (%)	**Steel production in the area in 1952** ($1000t$)	**Index of steed demand in the area in 1952** ($1000t$)
Belgium					
Bassin Sud	317629	5.3	8.34	5.2	22.5
	(64651)	(.8)			
Campine	187886	7.3	3.83	0.0	23.3
	(10049)	(1.0)			
France					
Aquitaine	41338	8.8	.81	.5	1.1
	(1822)	(1.6)			
Auvergne	22111	7.5	.45	.7	1.1
	(1597)	(1.2)			
Blanzy	50773	8.9	1.04	.7	1.1
	(1935)	(.8)			
Cévennes	53201	6.8	1.15	.7	1.1
	(6706)	(.7)			
Dauphiné	12516	7.9	.22	.7	1.1
	(1322)	(1.1)			
Loire	60791	7.3	1.37	.5	1.1
	(7524)	(.7)			
Lorraine	274368	11.4	5.4	7.1	22.2
	(18074)	(1.2)			
Nord PdC	547692	6.6	11.9	2.3	15.0
	(16066)	(.4)			
Autres mines	5724	6.2	.17	.2	.3
	(1847)	(1.3)			
Germany					
Aachen	148574	7.2	2.83	13.4	24.9
	(10795)	(1.4)			
Niedersachsen	45930	7.1	1.01	1.3	6.1
	(2465)	(1.8)			
Ruhr	2301753	8.7	49.12	13.4	24.9
	(72371)	(1.6)			
Saar	314134	8.7	6.92	2.8	22.4
	(11319)	(.6)			
Italy					
La Thuile	860	4.6	.03	3.0	.7
	(338)	(1.2)			
Sulcis	15532	5.0	.4	3.0	0.0
	(3250)	(1.5)			
Netherlands					
Limbourg	229536	7.8	5.0	.7	24.5
	(7358)	(1.0)			

NOTES: Statistics are computed from the *Statistiques Hebdomadaires* published by the Statistics Division of the High Authority of the European Coal and Steel Community. Standard deviations in parenthesis. Steel production in 1952 in the area computed from C.E.C.A., *Sixième rapport général, Annexe statistique*, tables 22 et 23 p.371. I matched steel centers to coalfields and considered that Aachen and Rurh corresponded to the same steel center (Ruhr and Aachen), Aquitaine and Loire where in the "Ouest" and Auvergne, Blanzy, Cévennes and Dauphiné in the"Centre" areas. Index of steel demand takes into account a weighted sum of steel production in 1952 within 400 km of each area (see text for further explanations).

in difference method, where UK is the control group. I use the UK as a control group as it was not affected by the policy changes in ECSC countries. UK is the

TABLEAU 1.4: **Descriptive statistics of the UK coalfields (1954-1962)**

	Average weekly production In tons	**Average weekly productivity** in Tons per worker	**Share of the coalfield in UK production in 1954** (%)
Durham	465000	4.9	12.35
	(27142)	(.2)	
East Midlands	875569	8.9	21.79
	(20942)	(.4)	
North Western	274509	5.3	7.46
	(30774)	(.3)	
Northern	227221	5.2	5.84
	(12870)	(.4)	
Scottish	380630	4.8	10.76
	(40440)	(.3)	
South Western	403040	4.1	11.38
	(48915)	(.1)	
West Midlands	312646	6.0	8.63
	(35283)	(.4)	
Yorkshire	820447	6.3	21.79
	(36912)	(.3)	

Statistics are computed from the yearly data of the *Colliery Year Book and Coal Trades Directory* published by the National Coal Board. Standard deviations in parenthesis.

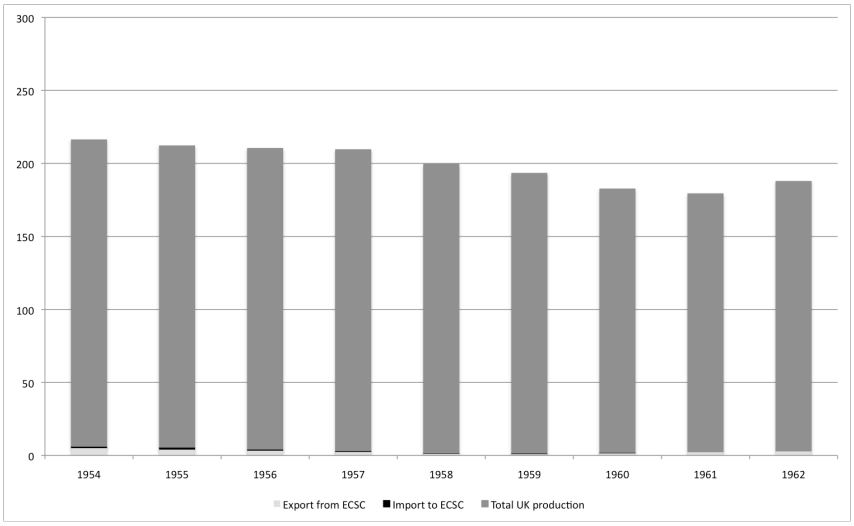
largest European coal producer, with a production equal to around 80 percent of the total production in ECSC countries. UK has a similar level of development than ECSC countries in 1950 and it is likely that technological changes in coal production would affect UK and other European countries in the same way. I checked that, despite the geographical proximity, coal exchanges between ECSC countries and the UK were relatively limited over the period. Figure 1.4 shows that the imports and exports between the UK and ECSC countries were almost negligible, relative to their production. I am therefore confident that changes in the competitive pressure in ECSC countries would not affect the UK directly, as the markets were not very well interconnected at this time.

UK coalfields can be used to control for any common shock that could have

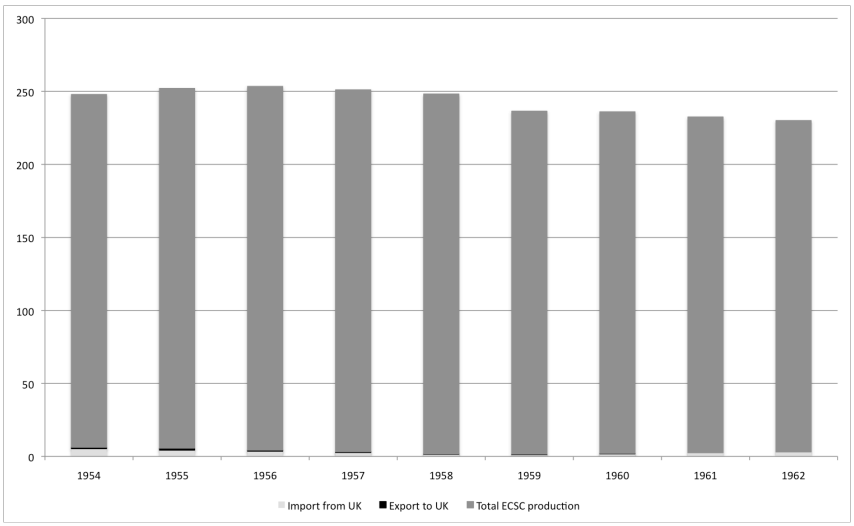
affected productivity after 1958. The identifying assumption is that absent the ECSC policy change, any productivity shock would have affected the UK and other countries in the same way. Figure 1.5 shows that productivity in UK and ECSC evolved similarly between 1954 and 1957. After the end of the transition period however, productivity increased significantly in ECSC countries whereas it evolved much more smoothly in the UK. As expected, the break in trend happens in 1958. The following empirical analysis confirms this suggestive evidence.

FIGURE 1.4: Evolution of productivity in ECSC and UK (1954 -1962)

(a) UK total coal production, and exchanges with the ECSC, 1954-1962



(b) ECSC total coal production, and exchanges with the UK, 1954-1962



NOTES: *Huitième rapport général*, C.E.C.A., 1960, *Annexe Statistique*, Tables 7, 8 and 19 and *Douxième rapport général*, C.E.C.A., 1964,*Annexe Statistique*, Tables 8, 9 and 11.

FIGURE 1.5: **Evolution of productivity in ECSC and UK (1954 -1962)**

NOTES: Average productivity is computed by weighting each coalfield by its share in production in ECSC or UK. ECSC statistics are computed from the *Statistiques Hebdomadaires* published by the Statistics Division of the High Authority of the European Coal and Steel Community. UK Statistics are computed from the *Colliery Year Book and Coal Trades Directory* published by the National Coal Board.

Specifically, I estimate the following model:

$$y_{ict} = \alpha + \beta.ECSC * Post1958 + \lambda_t + \nu_c + \epsilon_{it}, \tag{1.1}$$

where y_{ict} is the productivity of a coalfield i in country c at time t and $ECSC * Post1958$ is an indicator variable equal to 1 for ECSC countries after the end of the transition period (i.e. after 1958). The specification includes year fixed effects λ_t to control for common shocks at the European level that could affect productivity, and country fixed effects ν_c to control for fixed differences in

productivity across countries.[16] As a robustness check, I include coalfield fixed effects instead of country fixed effects in some specifications. The coefficient of interest is β, which measures how the productivity of coalfields located in ECSC country changed after the end of the transition period. One would expect β to be positive, if the end of the transition period yields to an increase in competitive pressure and productivity.

Robustness checks The specification from equation 1.1 allows me to assess whether the end of the transition period had an impact on productivity in ECSC coalfields. The validity of the difference-in-difference strategy is based on the assumption that, absent the ECSC policy change, any productivity shock would have affected the UK and other countries in the same way. In other terms, the post-1958 increase in productivity should be driven by ECSC coalfields' strategic decisions (and not from some technical change that would have affected all of the ECSC coalfields). ECSC coalfields' incentives to increase productivity depend on the size of the market to be served as the reduction of a given firm's marginal cost is all the more profitable that the demand that it serves is significant. I therefore analyze the differential effect of the end of the transition period as a function of the size of the market.

In order to analyze precisely whether the size of the market matters, I restrict the sample to ECSC coalfields, for which I have weekly production data. I use steel production as a proxy for the level of demand faced by each coalfield. Steel production is a good proxy for the industrial demand for coal, as steel industries are by far the largest consumers of coal in the 1950s (around 30 percent of total ECSC coal production is used for steel production in 1957).[17] Data on steel production in ECSC regional areas is available

[16]Note that the choice of a yearly analysis is driven by data limitations in the UK, as I was not yet able to access weekly data for all the period in the control group.

[17]This number comes from my calculations using data on coal and coke use in 1957 from

from ECSC reports. Table 1.3 shows the production of steel in the area of each coalfield in 1952 (note that steel areas may cover several coalfields).[18] The Ruhr/Aachen steel center is the largest, with 13,400 tons produced in 1952, followed by Lorraine (7,100t) and Bassin Sud (5,200t). This proxy for demand, however, does not reflect the fact that some areas are very close to each other. I therefore also calculate an index of steel demand (ISD), which takes into account a weighted sum of steel production in 1952 within 400 km of each coalfield. Weights are calculated as triangular weights: in order to take into account steel production in area j for coalfield i, I create a weight equal to : $w_i = 1 - d_i/400$ if the distance d_i between the two coalfields is less than 400 km and 0 otherwise. The two measures are correlated (see Table 1.3), but the index shows that coalfields located in the industrial triangle may serve a potentially large demand, even though steel production within their restricted area is relatively limited.

I estimate the following model, where I interact the variable indicating the end of the transition period in ECSC countries with D_i, the proxy for the demand faced by coalfield i:

$$y_{ict} = \alpha + \gamma.ECSC * Post1958 * D_i + \delta.D_i + \lambda_t + \nu_c + \epsilon_{it} \qquad (1.2)$$

The coefficient of interest is γ, which measures the differential effect of the end of the transition period on coalfields' productivity. I expect γ to be positive, as coalfields serving larger markets should have a higher incentive

the *Septième rapport général sur l'activité de la communauté*, C.E.C.A., 1959, p.54. Total coal production in ECSC in 1957 is equal to 189,846,000 tons. Around 40 percent is used for coke production, and 1.7 percent goes directly to the steel industry. Data on coke production shows that 68 percent of coke is used for steel production. The total amount of coal used in steel production is therefore equal to $68 * 0.4 + 1.7 = 28.9$.

[18] Using data from the *Sixième rapport général, Annexe statistique*, C.E.C.A., I match steel centers to coalfields. I consider that Aachen and Ruhr correspond to the same steel center (Ruhr and Aachen), Aquitaine and Loire where in the "Ouest" and Auverge, Blanzy, Cévennes and Dauphiné in the "Centre" areas.

to increase their productivity after the end of the transition period than coalfields located in smaller markets. Note that I cannot estimate the average effect of the end of the transition period, as we include year fixed effects that absorb the year-to-year changes in productivity that are common to all ECSC coalfields. I also run regressions where I include coalfield fixed effects instead of country fixed effects.

In the main analysis, I run the regression on the sample of all coalfields. As a robustness check, I restrict the sample to coalfields whose share of ECSC is larger than 1 percent in 1954, in order to ensure that small coalfields do not drive the results. I also checked that excluding Belgium, which continued to receive State Aid after 1958, does not change the results.

1.4.2 The differential effect of taxes and subsidies on productivity

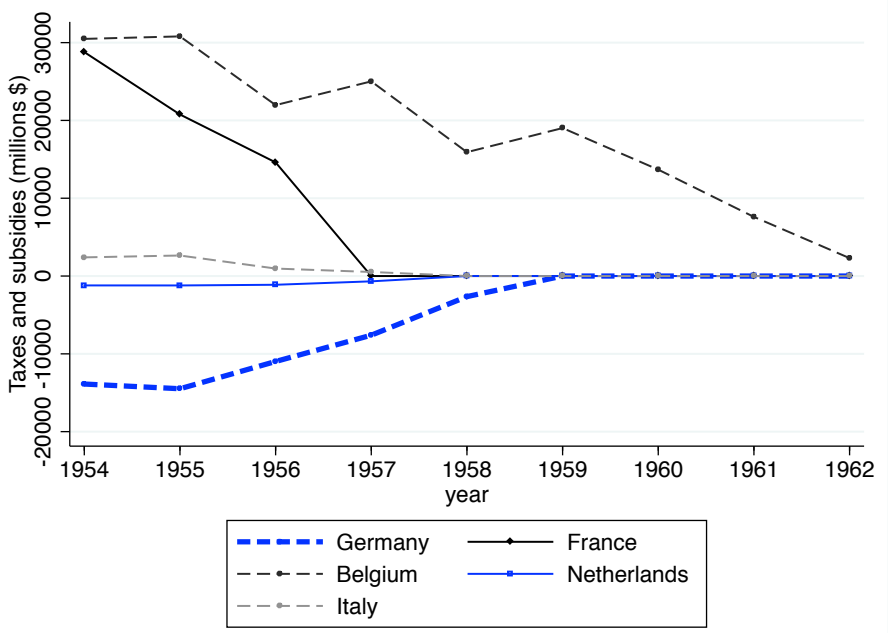
In the specifications presented so far, I analyze the global effect of the end of the transition period on productivity. I next study more precisely the differential effect of taxes and subsidies on productivity. I also investigate how taxes and subsidies may affect rationalization of production and investment in ECSC coalfields.

Figure 1.6 shows how total taxes and subsidies evolved over the period in ECSC countries. [19] The perequation system ended in 1958: all taxes paid and subsidies received from the perequation fund ended at this date. Even though French coalfields did not receive any subsidy from the ECSC fund, they were allowed to receive large state aids until 1956. Belgium benefited both from

[19]Data is available at the country level, as the detail on how subsidies were distributed is not specified for all coalfields.

state aid and subsidies in the perequation system. Moreover, as discussed in the previous sections, the High Authority allowed the Belgian government to give additional subsidies to its coalfields after 1958, but the authorization of these state aids was contingent upon the adoption of drastic rationalization measures.

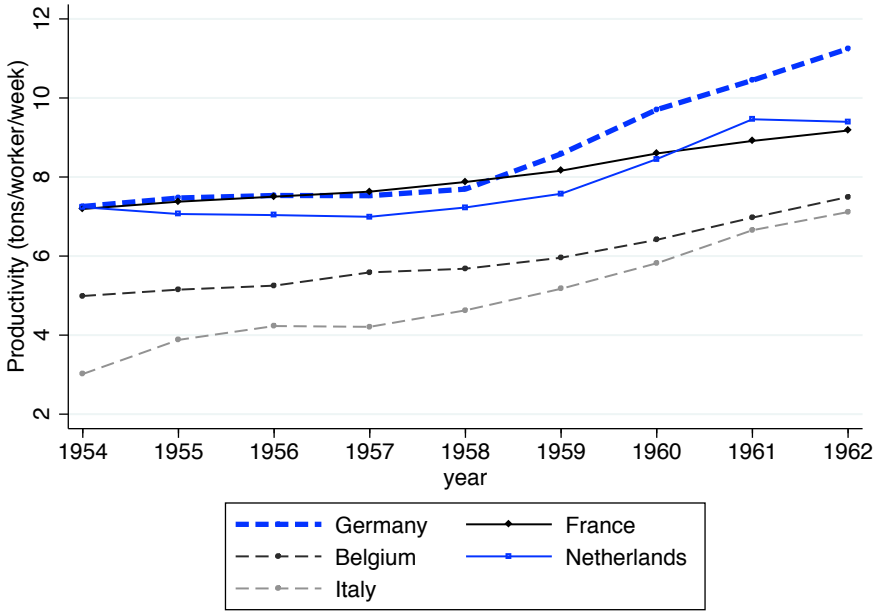
FIGURE 1.6: Evolution of taxes and subsidies in ECSC countries



SOURCES: ECSC General reports and Financial reports.

Figure 1.7 shows the corresponding evolution of productivity in ECSC coalfields: there is a clear break in trend for Germany and the Netherlands after 1958, the two countries that were previously taxed. Italy also shows large productivity gains, but Italian mines represent a tiny fraction of ECSC coal production. There is, however, no clear change after 1958 for France and Belgium. Even though both countries experience some productivity gains over the period, the end of the transition period does not seem to be associated

FIGURE 1.7: **Evolution of coalfield productivity countries**



SOURCES: *Statistiques Hebdomadaires* published by the Statistics Division of the High Authority of the European Coal and Steel Community.

with larger gains. These figures suggest that taxation had a deterrent effect on productivity, whereas the effect of subsidies seems to be ambiguous.

In order to test the differential effect of taxes and subsidies in ECSC coalfields, I run the following specification:

$$y_{ict} = \alpha + \gamma.Tax_{ict} + \delta.Subsidy_{ict} + X_t + \nu_c + \epsilon_{it} \tag{1.3}$$

The coefficients of interest are γ, which measures the effect of taxes on productivity, and δ, which measure the effect of subsidies.[20] All specifications include country or area fixed effects (ν_c), and I check that including a quadratic

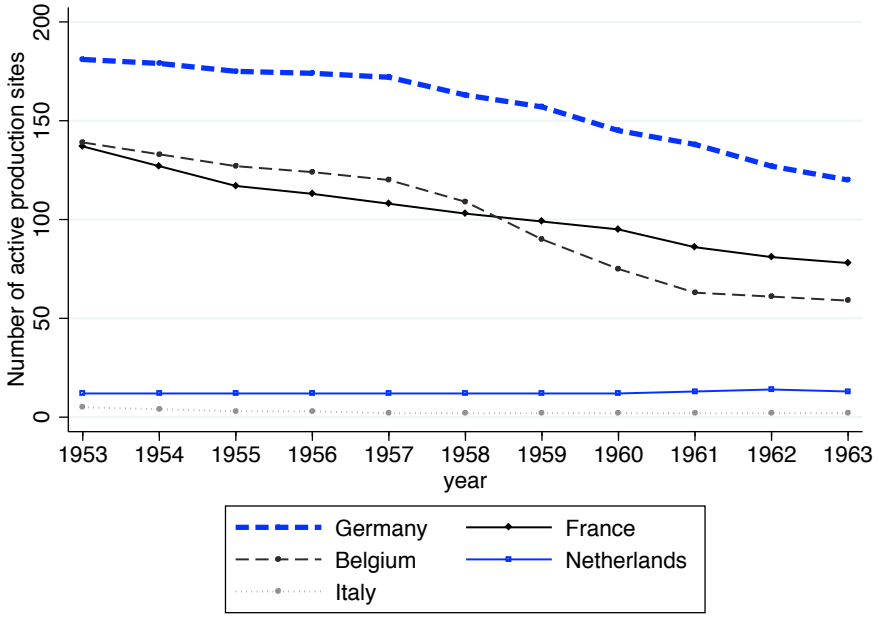
[20]Taxes and subsidies are measured yearly at the country level.

time trend or year fixed effects do not change the results. I chose to include the total amount of subsidies instead of per-unit measures, as state aids are often distributed as a lump sum. I also decided to analyze the contemporaneous effect of taxes and subsidies on outcomes (as opposed to lagged effects), since the ECSC perequation system was intended as a transitory policy, that should have a direct impact on productivity.

Finally, I also investigate the channels that may explain how coalfields increased their productivity. Coalfields have two main options to increase productivity: they can rationalize production or they can invest in new production technology. In order to rationalize production in the coal industries, firms can close the least efficient sites, which have the highest marginal cost of production. Figure 1.8 shows the evolution of active sites in ECSC countries: the total number of actives sites decreased from 474 in 1953 to 272 in 1964, but there is only a clear break in trend after 1958 for Belgium, which closed 45 sites between 1957 and 1960 (from 120 to 75).

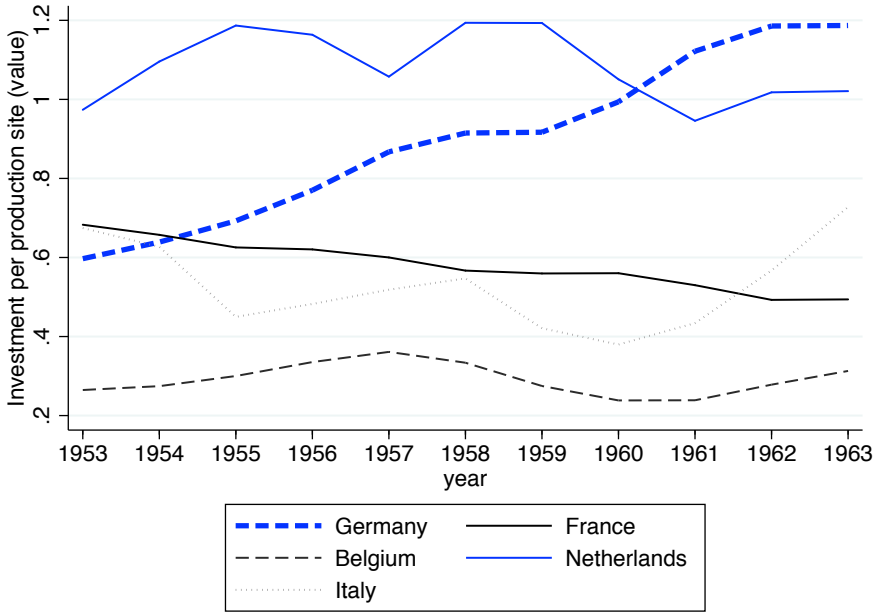
Firms can also invest in more efficient production technologies. Figure 1.9 shows the evolution of the amounts invested per active site between 1953 and 1964. There is no clear break in trend, but the figure suggests that investments tended to decrease over time in Belgium and France, whereas they increased in Germany. In order to analyze precisely the effect of taxes and subsidies, I run the same specifications as Equation 1.3, where the outcome variable is the number of active sites or the yearly investments per active site.

FIGURE 1.8: Evolution of the number of Active Sites in ECSC Coalfields



SOURCES: Author's calculations from ECSC archives.

FIGURE 1.9: Investments per Active Sites in ECSC Coalfields (Value)



SOURCES: Author's calculations from ECSC archives.

NOTES: Series have been smoothed using running-mean smoothing.

1.5 Results and interpretation

In this section, I show how the transition period affected coalfields' productivity. Furthermore, I show that taxes significantly deterred mines to make productive investments, thereby increasing their productivity. Finally, subsidies also failed to significantly increase investment and productivity of the recipient mines. I discuss these results, explaining why the High Authority did not succeed in giving Belgian mines the adequate incentives to make the productive investments that would allow them to face fierce competition within the common market for coal.

1.5.1 Results

The impact of the end of the transition period

The main estimation strategy I first perform the difference-in-difference regression using the yearly UK and ECSC samples. Table 1.5 shows the result of the basic specification, with country and year fixed effects (column (1)). The end of the transition period is associated with a significant increase of productivity of 1.217 weekly tons per worker, which corresponds to a 18 percent increase compared to the average productivity in ECSC in 1954. These results are robust to the inclusion of area fixed effects (Column (2)).[21] Results are unchanged if the smallest coalfields are excluded (Columns (3) and (4)) and when Belgium is left out of the sample (Columns (5) and (6)).

[21] Standard errors are robust, but not clustered, as the number of clusters is too small to apply standard clustering methods.

TABLEAU 1.5: Effect of the end of the transition period on productivity in ECSC coalfields - Annual ECSC and UK Samples (1954-1962)

	(1)	(2)	(3)	(4)	(5)	(6)
After 1958 in ECSC	1.217*** (0.402)	1.217*** (0.132)	1.265*** (0.436)	1.265*** (0.115)	1.229*** (0.413)	1.229*** (0.413)
Year f.e.	YES	YES	YES	YES	YES	YES
Country f.e.	YES	NO	YES	NO	YES	NO
Coalfield f.e.	NO	YES	NO	YES	NO	YES
Obs.	234	234	180	180	216	216
R^2	0.514	0.916	0.486	0.957	0.514	0.913

NOTES: Dependent variable is the average weekly productivity per worker over the year in each coalfield. The sample in columns (1) and (2) comprises all coalfields; the sample in columns (3) and (4) exclude coalfields which produce less than 1 percent of total ECSC production ; the sample in columns (5) and (6) excludes Belgium. Robust standard errors in parentheses. Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Robustness check I then analyze the differential effect of the end of the transition period using the weekly data on productivity in ECSC coalfields, in order to check whether the post-1958 increase in productivity was driven by coalfields' strategic decisions (and rule out the effect of an exogenous technological shock, which would have affected all the ECSC coalfields in a similar way).

Tables 1.6 and 1.7 show the results of the specification that includes an interaction between the variable indicating the end of the transition period in ECSC countries and a proxy for coal demand in the area. In Table 1.6, the proxy for coal demand is steel production in each coalfield's area. The coefficient has the expected sign and is significant in all specifications, with country fixed effects (column (1)) and coalfield fixed effects (column (2)). In my preferred specification, which includes coalfield fixed effects, the coefficient is equal to 0.0524. This means that an increase in steel demand in the area by 13,000t (which correspond to the differential in demand between

coalfields located in the Ruhr/Aachen area and coalfields located in the Centre of France) yields to an increase in productivity of 0.68t per worker after the end of the transition period. The coefficients increases slightly to 0.0749 when small coalfields are excluded from the analysis (columns (3) and (4)), and remains unchanged when Belgium is left out of the sample (columns (5) and (6)).

TABLEAU 1.6: Differential effect of the end of the transition period on productivity by level of steel demand in the area - Weekly ECSC sample (1954-1962)

	(1)	(2)	(3)	(4)	(5)	(6)
After 1958	0.0518***	0.0524***	0.0737***	0.0749***	0.0546***	0.0554***
x Steel production	(0.00706)	(0.00337)	(0.00686)	(0.00335)	(0.00747)	(0.00342)
Year f.e.	YES	YES	YES	YES	YES	YES
Country f.e.	YES	NO	YES	NO	YES	NO
Coalfield f.e.	NO	YES	NO	YES	NO	YES
Obs.	8,040	8,040	5,387	5,387	7,151	7,151
R^2	0.494	0.810	0.409	0.868	0.505	0.803

NOTES: Dependent variable is the weekly productivity per worker in each coalfield. Steel production in the area in 1952 is used as a proxy for coal demand.The sample in columns (1) and (2) comprises all coalfields; the sample in columns (3) and (4) exclude coalfields which produce less than 1 percent of total ECSC production; the sample in columns (5) and (6) excludes Belgium. Robust standard errors in parentheses. Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

The results are qualitatively similar when I use the index of steel demand instead of demand in the area (Table 1.7), but the magnitude of the coefficients is smaller. In the specification including coalfields fixed effects (column (2)), the coefficient is equal to 0.0108. For an increase in aggregate steel demand by around 24,000t (which corresponds roughly to the difference between coalfields located in the Ruhr/Aachen area and coalfields located in the Centre of France), the increase in productivity would be around 0.26t per worker. Excluding the smallest coalfields yields similar results. These re-

TABLEAU 1.7: Differential effect of the end of the transition period on productivity using an aggregate index of steel demand - Weekly ECSC sample (1954-1962)

	(1)	(2)	(3)	(4)	(5)	(6)
After 1958 x ISD	0.0110***	0.0108***	0.0119***	0.0121***	0.0142***	0.0143***
	(0.00256)	(0.00173)	(0.00302)	(0.00175)	(0.00283)	(0.00184)
Year f.e.	YES	YES	YES	YES	YES	YES
Country f.e.	YES	NO	YES	NO	YES	NO
Coalfield f.e.	NO	YES	NO	YES	NO	YES
Obs.	8,040	8,040	5,387	5,387	7,151	7,151
R^2	0.559	0.808	0.504	0.860	0.554	0.801

NOTES: Dependent variable is the weekly productivity per worker in each coalfield. Index of steel demand takes into account a weighted sum of steel production in 1952 within 400 km of each area (see text for further explanations). The sample in columns (1) and (2) comprises all coalfields; the sample in columns (3) and (4) exclude coalfields which produce less than 1 percent of total ECSC production; the sample in columns (5) and (6) excludes Belgium. Robust standard errors in parentheses. Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

sults confirm the fact that the post-1958 increase in productivity was driven by coalfields' unilateral strategic decisions, and rule out the alternative hypothesis that this significant increase in productivity would be caused by any macroeconomic or technical change.

The differential impact of taxes and subsidies on coalfields' productivity

The last set of results shows the differential effect of taxes and subsidies on productivity. It also specifies how both taxes and subsidy impact coalfields' rationalization and investment decisions.

Table 1.8 shows that taxes and subsidies both negatively affects weekly productivity in ECSC coalfields. These effects are significant in all specifications, without time effects (column (1)), including a quadratic time trend

(column (2)), or controlling for time effects with a full set of year dummies (column (3)). The results are also robust to the exclusion of the smallest coalfields (column (4)), and of Belgium (column (5)) from the sample. The fact that estimates are unaffected by the exclusion of Belgium, which received state aids throughout the entire period, suggests that the results are mainly driven by the end of the perequation system. Coefficients from my preferred specification (column (3)), which include area and time effects, suggest that a $10m tax decreases productivity by about 1, and a $10m subsidy decreases productivity by approximately 0.4.

TABLEAU 1.8: Effect of taxes and subsidies on productivity in ECSC coalfields

	(1)	(2)	(3)	(4)	(5)
Taxes	-0.000160***	-8.00e-05***	-9.70e-05***	-6.53e-05***	-0.000113***
	(3.89e-06)	(5.72e-06)	(5.84e-06)	(4.32e-06)	(6.54e-06)
Subsidies	-6.82e-05***	-3.30e-05***	-4.06e-05***	-1.18e-05***	-5.29e-05***
	(1.10e-06)	(2.75e-06)	(2.95e-06)	(1.89e-06)	(3.45e-06)
Coalfield f.e.	YES	YES	YES	YES	YES
Quadratic time trend	NO	YES	NO	NO	NO
Year f.e.	NO	NO	YES	YES	YES
Obs.	8,040	8,040	8,040	5,387	7,151
R^2	0.733	0.811	0.817	0.865	0.814

NOTES: Dependent variable is the average weekly productivity per worker over the year in each coalfield between 1954 and 1962. The sample in columns (1) to (3) comprises all ECSC coalfields; the sample in column (4) exclude coalfields which produce less than 1 percent of total ECSC production and the sample in column (5) excludes Belgium. Robust standard errors in parentheses. Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Next, I investigate whether taxes and subsidies have an impact on the rationalization of coal mines, as measured by the number of active sites. Results, presented in Table 1.9, show that neither taxes and subsidies seem to have any significant effect on the closing of active sites, once I control for time effects (column (2) and (3)). Excluding Belgium does not change this result.

Finally, I analyze the impact of taxes and subsidies on the level of investment per active site. Table 1.10 shows a clear negative impact of taxes on investment, whereas the effect of subsidies is never significant. The effect on taxes is robust to the inclusion of a quadratic time trend (column (2) or year dummies (column (3)). Excluding Belgium reduces the sample and decreases precision, but the negative effect of taxes is still significant at the 10 percent level. These results suggest that subsidies were not used for productive investment during the transition period. On the other hand, as expected, taxes levied through the perequation system had a clear negative impact on investment decisions.

TABLEAU 1.9: Effect of taxes and subsidies on the number of active sites in ECSC countries

	(1)	(2)	(3)	(4)
Taxes	0.000673	7.07e-05	0.000163	0.000496
	(0.00148)	(0.00172)	(0.00179)	(0.00176)
Subsidies	0.000636*	0.000340	0.000375	0.000287
	(0.000365)	(0.000559)	(0.000548)	(0.000607)
Country f.e.	YES	YES	YES	YES
Quadratic time trend	NO	YES	NO	NO
Year f.e.	NO	NO	YES	YES
Obs.	121	121	121	99
R^2	0.127	0.133	0.133	0.119

NOTES: Dependent variable is the number of active site in broadly defined coalfields between 1953 and 1963. Column (1) to (3) includes all ECSC countries, column (4) excludes Belgium. Robust standard errors in parentheses. Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

TABLEAU 1.10: Effect of taxes and subsidies on investment per active site in ECSC countries

	(1)	(2)	(3)	(4)
Taxes	-4.30e-05***	-3.79e-05**	-5.20e-05**	-4.12e-05*
	(7.13e-06)	(1.48e-05)	(2.51e-05)	(2.22e-05)
Subsidies	1.75e-05	2.12e-05	1.92e-05	1.49e-05
	(1.20e-05)	(1.42e-05)	(1.47e-05)	(1.45e-05)
Country f. e.	YES	YES	YES	YES
Quadratic time trend	NO	YES	NO	NO
Year f. e.	NO	NO	YES	YES
Obs.	121	121	121	99
R^2	0.119	0.122	0.140	0.183

NOTES: Dependent variable is investment per active site in large coalfields (in value) between 1953 and 1963. Robust standard errors in parentheses. Column (1) to (3) includes all ECSC countries, column (4) excludes Belgium. Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

1.5.2 Discussion

There are two main reasons that may explain why the subsidies granted to the less efficient mines failed to increase productive investments and therefore to enhance productivity.

First, the Belgian mines could expect to stay eligible for future financial support if they remained less efficient than other ECSC coalfields. Therefore, Belgian coalfields were not given the correct incentives to rationalize their production process and make the necessary productive investments. There is historical evidence that these subsidies were not invested in order to increase productivity and prepare Belgian coalfields to compete within the Common Market. For instance, in February 1959, the Belgian Prime Minister admitted that the subsidies were not used to take the necessary reorganization measures and increase the productivity of Belgian mines. [22] In 1959, a few news-

[22] *Les difficultés du marché charbonnier - Commentaires et Critiques, Assemblée Parlementaire*

papers criticized the "negligence" of the past Belgian Governments regarding the rationalization of the Belgian mines.[23] The Belgian Dutch-speaking daily newspaper *De Tijd*, dated February 19, 1959, clearly assessed that the Belgian mine owners allocated the subsidies that they were granted to by the Dutch and German mines from 1955 to 1957 to directly compensate their high production costs instead of making the requested productive investments.

Second, both the Belgian State and the High Authority were probably not credible enough in 1954 to commit to cease the subsidies in 1958 if the Belgian mines were not ready to compete on the merits within the Common Market for coal and steel. In 1958, the Belgian State could not accept to cease the subsidies, which would have considerably reduced its home coal production. This explains why the Belgian State provided its less efficient mines with financial support even after the end of the transition period, even though such a decision went against the ECSC Treaty. The subsidies granted to Belgian mines in the 1950s is an example of dynamic inconsistency. Putting a definitive end to the subsidies in 1958 was not a politically acceptable solution, even though it was a necessary condition to induce the Belgian mines to make the needed productive investments during the transition period. This illustrates the fact that the institution that provides short-term subsidies must be able to commit to put a definitive end to the aids whatever the situation of the recipient.

Européenne, January-March 1959, p. 8.

[23] See for instance, *De Nieuwe Gids* dated February 17 and 22, 1959; *Het Parool*, dated February 18; or the Dutch newspaper *De Nederlandse industrie*, dated March 1, 1959.

1.6 Conclusion

This paper shows that the subsidy system implemented by the High Authority of the ECSC deterred coalfields form increasing their productivity. I use coalfields in the UK, which were not affected by the policy changes in ECSC countries, as a control group to precisely capture the effect of the end of the transition period. The perequation system did not have the expected effects. It failed to encourage the less efficient mines to make the necessary investments to face fierce competition. As the Commission of the European Communities mentions, the objective of the transition period was to "*operate the investments of rationalization in order to allow the coal producers to integrate the common market without artificial safe harbors.*"[24] It concludes that "*the steps taken towards modernizing the coalfields were limited.*"[25]

The conclusion of this paper goes further the historical example of the ECSC. I show that short-term taxes levied on productive firms have a clear deterrent effect both on their investments and productivity. Furthermore, short-term subsidies, which are still a popular industrial policy do not always give firms incentive to make productivity-increasing investments. More precisely, there are two main reasons why the subsidies granted to ECSC coalfields did not end up increasing mine productivity. First, subsidies were designed in such a way that only the least efficient mines were granted some financial support. This clearly distorted incentives to make productivity-increasing investments. On the contrary, mines were given incentives to stay less productive in order to remain eligible for financial support. Furthermore, the level of the subsidy depended on the level of the marginal cost of the eligible mine. A productivity-increasing investment, which precisely consists in decreasing

[24] *25 ans de marché commun du charbon*, p.74, Author's translation.
[25] *25 ans de marché commun du charbon*, p.74, Author's translation.

marginal cost, would have implied a lower future subsidy – if any. Second, efficient subsidy policies raise the well-identified issue of time-consistency of optimal plans: the institution has to be able to commit to cease the financial support even though the recipient is still less efficient than its rivals. The example of the transition period carried out by the ECSC shows that the credibility of the institution (generally the State) that provides financial support to firms is a key element of the success of the policy.

Appendix: Sources

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2. UK: *Colliery Year Book and Coal Trades Directory* published by the National Coal Board.

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http://aei.pitt.edu/view/eusubjects/ecasc.html

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CHAPTER 2

REPEATED PURCHASES, LOYALTY REBATES, AND DEMAND FORECLOSURE

2.1 Introduction[1]

Firms face heterogeneous customers. Demand often consists in *recurrent* buyers, who purchase repeatedly, and *occasional* customers, who only buy once. Typically, airlines serve both frequent travelers and tourists. It is also common for producers to deal with retailers of various size. This paper analyses how demand heterogeneity can allow an incumbent to implement loyalty rebates (or discounts) that deny a rival scale, thereby profitably deterring efficient entry.

Loyalty rebates are extremely common pricing strategies, which have be-

[1]I thank Larbi Alaoui, Claudio Calcagno, Gabrielle Fack, Chiara Fumagalli, Matthias Hunold, Liliane Karlinger, Chrysovalantou Milliou, Massimo Motta, Anne Perrot, David Spector, Yossi Spiegel, and Thibaud Vergé, as well as seminar participants at Universitat Pompeu Fabra (Barcelona, Spain), Centre for Competition Policy (Norwich, UK), 7^{th} International Conference on Competition and Regulation (CRESSE, Chania, Greece), 2013 MaCCI Annual Conference (ZEW, Mannheim, Germany). The usual disclaimer applies.

come an important topic in competition policy. In the US, they are often considered pro-competitive, as they tend to reduce prices and give retailers strong incentives to increase downstream demand.[2] Under European law, there is an important distinction between "standardized" discounts, which are based on generally applicable sale thresholds, and "individualized" rebates defined by customer-specific sale targets.[3] The former are presumed legal while the latter are considered in most cases unlawful as they imply explicit (first-degree) discrimination. Several cases like Intel,[4] which was fined more than one billion euro, or Deutsche Post[5] precisely illustrate the fact that individualized rebates can be granted in order to deprive an efficient rival of the scale it needs to profitably enter the market.[6]

One of the main contributions of this paper is to show that, under demand heterogeneity, loyalty rebates are *always* more profitable for the dominant firm than independent pricing, as they allow the incumbent either to prevent the efficient rival from entering the market or to extract all or part of the entrant's rent. Moreover, I show that the incumbent can deter efficient entry by implementing a standardized rebate scheme, as it induces customers to select themselves according to their type. Knowing each customer's type would not increase the profit that the incumbent can achieve granting standardized rebates. Furthermore, when the degree of demand heterogeneity is too low to separate customers according to their types, the incumbent may profitably grant the same loyalty rebate to all customers in order to deter en-

[2]See Kobayashi (2004) for a review of the most important US cases involving loyalty rebates.

[3]See Case T-203/01 Michelin v. Commission [2003] ECR II-4071. For a detailed economic analysis of the recent European case law, see O'Donoghue et Padilla (2006).

[4]European Commission Decision COMP/C-3/37.990, 13 May 2009 ("Intel").

[5]European Commission Decision COMP/35.141, 20 March 2001 ("Deutsche Post").

[6]See e.g. "Deutsche Post:" "*By granting fidelity rebates to its biggest partners,* [Deutsche Post] *has deliberately prevented competitors from reaching the "critical mass" of some 100 million in annual turnover*," which is required for successful entry (§37).

try. Finally, I show that *optimal* entry-deterrent discounts are characterized by a first-period list price above the monopoly price and a second-period discounted price below the incumbent's marginal cost. This particularly high first-period price balances the low second-period one, thereby allowing the incumbent to profitably deter entry. This pricing scheme is commonly implemented in practice: the subscription business model, for instance, precisely consists in setting an initial fixed fee in exchange for the long-period provision of a good at a very low (if not zero) price. This pricing strategy diametrically differs from other exclusionary practices, which generally amounts to charge very low first-period prices, either to directly deter entry (predation) or to preempt demand (exclusive dealing) before charging monopoly prices when enjoying the leveraged dominant position. In an extension of the basic model, I show that, when customer heterogeneity is limited, exclusion can be driven by "buyer opportunism:" customers buy unneeded units of the good from the incumbent in order to benefit from the rebates.

Ties to the literature To my knowledge, the anticompetitive consequences of such optimal loyalty rebates have never been studied in the literature. However, this paper is directly related to both seminal papers on exclusive dealing contracts by Rasmusen et al. (1991) and Segal et Whinston (2000) (henceforth RRW and SW). As RRW and SW, I assume that the efficient rival must serve a minimum number of customers to recoup its fixed entry cost.[7] However, my work differs from these two papers in many respects. First, in RRW and SW's models, customers' preferences are assumed to be symmetric. In my

[7]Following RRW and SW, various other papers are based on this assumption. Carlton et Waldman (2002) and Fumagalli et Motta (2009) respectively analyze bundling and predation, in a setting where there are "occasional" customers only. Fumagalli et Motta (2006) discuss the consequences of competition amongst buyers in RRW's and SW's framework. Spector (2011) adapts such a model to the situation where the incumbent excludes a more efficient firm already active on the market, by proposing exclusive dealing contracts to symmetric customers.

model, profitable entry deterrence comes from customer heterogeneity. Second, RRW and SW consider exclusive dealing contracts: foreclosure results from customer preemption. Loyalty rebates do not imply customer preemption as the rival, if it decides to enter, can serve *all* second-period customers. Buyers simply observe prices and decide which firm to purchase from, without having to comply with any contract. Therefore, customers do not need to commit and have no incentive to renegotiate their pricing conditions. Finally, conditions for successful entry deterrence also differ. In this paper, customers' miscoordination is not a necessary condition for profitable entry deterrence, and there is no need for the incumbent to explicitly discriminate amongst customers in order to profitably prevent the efficient firm from entering the market.

This paper is also related to the economic literature on rebates. Karlinger et Motta (2012) study whether pure quantity discounts can have entry-deterrent effects and show that explicit (i.e., first-degree) price discrimination is more effective to deter entry than uniform pricing. However, if entry occurs, explicit discrimination achieves the highest level of welfare. There is therefore a trade-off for the regulator between maximizing the chances of entry and maximizing consumer welfare. In their paper, as in RRW's, entry deterrence results from customers' miscoordination. Federico et Régibeau (2012) show that rebates can significantly distort competition in a situation where asymmetric firms sell their products through an intermediary who can favor a firm over the other. However, as the authors point out, foreclosure crucially results from the role played by the recipients of the incentive payments, and their findings cannot be directly applied "*to cases where rebates are paid to final or intermediate consumers (which is typically the case when one deals with*

loyalty discounts)."[8] Karlinger (2012) shows that rebates can be granted by a dominant upstream firm in order to control retailer competition: the incumbent can design a rebate scheme to accommodate entry, as in Aghion et Bolton (1987). Rebates allow it to secure its profit and to reduce the rents that its rivals could extract from the retailers. Similarly, I show that loyalty rebates allow the incumbent to extract part or all of the rival's rent but, if the incumbent's marginal cost is lower than a given threshold, entry deterrence is more profitable than entry accommodation. Finally, Choné et Linnemer (2013) analyze an exclusionary scenario for quantity rebates and market share discounts when the buyer and the incumbent do not know ex ante the quality of the good. The incumbent can design a rebate offer in order to extract all or part of its rival's rent. Choné et Linnemer (2013) introduce the idea of "buyer opportunism:" the buyer might buy unneeded units of the good with the sole purpose of pocketing rebates. In their model, this strategy is never seen in equilibrium. On the contrary, I show that, when it is not too costly for a customer to purchase additional units in period 1 in order to benefit from the rebate in period 2, buyer opportunism leads to entry deterrence.

The rest of the paper is organized as follows: Section 2 presents the model, Section 3 discusses the main results, focusing on the optimality of the pricing scheme and the conditions for successful entry deterrence, and Section 4 concludes.

2.2 Optimal loyalty rebates

This section presents the baseline model, where first-period demand structure consists in both recurrent and occasional customers. I show that the

[8] Federico et Régibeau (2012), p. 3.

incumbent can accommodate or deter entry by implementing an optimal rebate scheme such that first-period customers select themselves according to their type (i.e., implicit or second-degree discrimination).

2.2.1 The model

I consider a two-period game where an incumbent (I) and a potential entrant (E) produce a homogenous good, and face the same number N of customers in each period ($N \geq 2$). Amongst these customers, R are *recurrent* buyers – as they periodically buy one unit of good ($R \geq 1$), and $N - R$ are *occasional* customers, who only buy once. The type of a customer (i.e., *recurrent* or *occasional*) is private information. Each customer demands one unit of good for any price weakly lower than $v = 1$.[9]

In period 1, the incumbent, which enjoys monopoly power, proposes a menu of prices $\mathcal{M} = \{(\overline{p}, \underline{p}); p_{I1}\}$ to all first-period customers, where $\overline{p}$ and $\underline{p}$ ($\overline{p} > \underline{p}$) define the rebate offer; $\overline{p}$ (resp. $\underline{p}$) is to be paid in period 1 (resp. in period 2); and p_{I1} is the stand-alone first-period price. In other words, a first-period customer is offered the choice between purchasing one unit at a price p_{I1} or buying it at a price $\overline{p}$, which gives him the opportunity to buy another unit in period 2 at a discounted price $\underline{p}$. I assume non-negative prices.[10]

Customer i's intertemporal utility, when accepting the rebate offer, is denoted $U^i(r) = U^i(\overline{p}, \underline{p}) = (1 - \overline{p}) + \delta(1 - \underline{p})$. Similarly, $\Pi_I = \Pi_{I1} + \delta\Pi_{I2}$ is Firm

[9] All the findings remain when considering a linear demand function: there is a minimum quantity $\overline{q}$ that needs to be purchased by recurrent customers in period 1 in order to benefit from the rebate scheme.

[10] Assuming negative discounted prices would be a way to model *retroactive* (or *all-unit*) rebates, which are discounts granted on all units conditional on reaching a given quantity or expenditure threshold. In such a case, it can thus be cheaper for a customer to increase the quantity he purchases in order to reach the threshold. I restrict my attention to situations where the total price charged to customers is weakly increasing with the quantity purchased. Allowing for negative discounted prices (i.e., retractive rebates) would make entry deterrence even easier.

I's intertemporal profit, where Π_{It} $(t = \{1, 2\})$ is its profit in period t. δ is a discount factor; I assume non-myopic agents $(1 \geq \delta > 0)$.

Firm E decides whether or not to enter the market in period 2. If it enters, both firms compete *à la Bertrand*. Firm E's marginal cost is strictly lower than the incumbent's $(c_E = 0 < c_I < 1)$. If it enters, Firm E has to incur a sunk fixed entry cost f, which can be recouped only if it serves a minimum number of second-period customers equal to $\underline{N}+1$: $\underline{N}$ is therefore the greatest integer such that

$$\underline{N}c_I < f < Nc_I. \tag{A1}$$

This assumption ensures that *(i)* it is profitable for Firm E to enter the market if it can serve at least $\underline{N} + 1$ customers as Firm E's profit when entering the market is given by $\Pi_E = (\underline{N}+1)p_E - f = (\underline{N}+1)c_I - f$, which is non negative, and *(ii)* Firm E's entry is socially beneficial.

Finally, I assume that (i) first-period customers' choices are public information in period 2, and (ii) the entrant is free to explicitly discriminate amongst second-period customers. These last two assumptions make entry deterrence much more difficult because they allow the entrant to undercut $\underline{p}$ and charge a higher price to customers who do not benefit from the rebate offer.

The timeline of the game is as follows.

1. First period.

   i. Firm I proposes a menu of non-negative prices $\mathcal{M} = \{(\overline{p}, \underline{p}); p_{I1}\}$.

   ii. Each customer decides whether or not to buy one unit of good. If he decides to buy one unit from the incumbent, he has to choose between accepting the rebate offer and paying the stand-alone price p_{I1}. Finally, first-period transactions take place.

2. Second period.

i. Firm E decides whether or not to enter the market, knowing first-period customers' choices, which are public information.

ii. Firm E, if it decided to enter, and Firm I simultaneously set second-period prices (p_{I2} and p_E). Recurrent customers who accepted the rebate offer and paid $\overline{p}$ in period 1 can buy another unit in period 2 at a price $\underline{p}$.

iii. Buyers decide from which firm to buy, and second-period transactions take place.

2.2.2 Independent pricing

As a baseline, I consider the benchmark situation in which the incumbent does not implement any rebate scheme. This situation also corresponds to the case in which there is no recurrent customer ($R = 0$). The two periods of the game are therefore independent and can be analyzed as two different games.

During the first period, the incumbent charges $\tilde{p}_{I1} = 1$ to each first-period customer, and gets a first-period profit $\tilde{\Pi}_{I1} = N(1 - c_I)$.

During the second period, Firm E decides to enter the market. Both firms simultaneously set $\tilde{p}_E = \tilde{p}_{I2} = c_I$, Firm E serves all second-period customers, and makes a profit $\tilde{\Pi}_E = Nc_I - f > 0$.

2.2.3 Definition: "Standardized" vs. "individualized" rebates

A firm implements a *standardized rebate* scheme when it proposes the same rebate offer to all customers (whether each customer accepts it or not). An *individualized rebate* scheme would allow the incumbent to restrict to any n^*

($n^* < N$) the number of rebates $(\overline{p}, \underline{p})$ that it proposes to first-period customers.

2.2.4 Analysis

Optimal partially exclusionary standardized rebates I show that an optimal loyalty rebate is defined by a high first-period price and a low second-period one. The incumbent can thus implement such a rebate in order to benefit from the high first-period price and let the efficient entrant provide the good at a reduced price in period 2. Therefore, the incumbent can grant a rebate offer in order to accommodate entry and extract all or part of its rival's rent.[11]

Partially exclusionary rebates always yield a higher profit than independent pricing. Proposition 1 formally presents this result. Recall that $\underline{N} + 1$ is the minimum number of customers that Firm I needs to serve in order to be able to recoup its fixed entry cost. I define $N^* = N - \underline{N}$, where N is the total number of customers to be served in each period.

Proposition 1. *The incumbent can implement a rebate offer in order to accommodate entry for any $R > 0$, $N \geq 2$, c_I, and f that satisfy (A1). Entry accommodation is always more profitable than independent pricing.*

1. *If $R < N^*$, the optimal menu of prices that Firm I can implement in order to accommodate entry is given by $\mathcal{M}^* = \{(1 + \delta(c_I - \epsilon), \epsilon); 1\}$, where ϵ is strictly positive and tends to 0. In period 1, all recurrent customers choose the rebate offer, while all occasional customers choose to pay the standalone price $p^*_{I1} = 1$. Firm I's profit is $\Pi_I^{EA} \approx N(1-c_I)+\delta R c_I$. In period 2,*

[11] Aghion et Bolton (1987) show that exclusionary contracts can be used to extract their rival's rent. However, a striking difference with Aghion's and Bolton's paper is that exclusion would never take place in the deterministic version of their model. Exclusion may only take place when there is uncertainty about the efficiency of the entrant, which is not the case here (see Proposition 2).

Firm E decides to enter, charges $\underline{p}_E = \epsilon$ to the recurrent customers, $p_E = c_I$ to the occasional customers, and gets a profit $\Pi_E^{EA} \approx (N - R)c_I - f$.

2. *If $R \geq N^*$, the optimal menu of prices that Firm I can implement in order to accommodate entry is given by $\mathcal{M}^* = \{(1 + \delta(c_I - \kappa), \kappa); 1\}$, where $\kappa = \frac{1}{R}[f - (N - R)c_I]$. Firm I's profit is given by $\Pi_I^{EA} = N(1 - c_I) + \delta\rho_E$, where $\rho_E = Nc_I - f$ is Firm E's rent. In period 2, Firm E decides to enter, charge $\underline{p}_E = \kappa$ to the recurrent customers, $p_E = c_I$ to the occasional customers, and makes no profit: $\Pi_E^{EA} = 0$.*

Proof. See Appendix. □

As Proposition 1 shows, two cases can be distinguished. If the number of recurrent customers is low ($R < \underline{N}$), the entrant can recoup its fixed entry cost only serving second-period occasional customers. Therefore, the incumbent can only extract the share of Firm E's rent that comes from recurrent customers' second-period purchases. If the number of recurrent customers is high ($R \geq \underline{N}$), the incumbent can extract Firm E's entire rent (ρ_E) by charging a discounted price ($\underline{p}$) such that the total amount paid by second-period customers equals the entrant's fixed entry cost.

Optimal entry-deterrent standardized rebates I show that there is a set of optimal standardized rebates that allows the incumbent to deter entry if *(i)* there is at least one occasional customer, and *(ii)* the number of recurrent customers is high enough. Moreover, I show that entry deterrence is more profitable than entry accommodation if the number of recurrent customer is low enough: $R < \overline{N}(c_I) = \frac{(1-2c_I)N+f}{1-c_I}$. An equivalent condition is that Firm I's marginal cost is lower than a given threshold: $c_I < \overline{c_I} = \frac{N-R+f}{2N-R}$.

Optimal entry-deterrent rebates, like partially exclusionary ones, are characterized by a very high first-period price ($\overline{p}$), which allows the incumbent to

commit to a very low second-period price ($\underline{p}$). The high first-period price of the rebate offer is greater than customers' willingness to pay for one unit of good ($\overline{p} > 1$), while the second-period reduced price is lower than Firm I's marginal cost ($\underline{p} < c_I$). The first-period price thus balances the second-period one, thereby considerably increasing the profitability of entry deterrence.

Furthermore, the menu of prices $\mathcal{M} = \{(\overline{p}, \underline{p}); p_{I1}\}$ is incentive compatible because no first-period occasional customer would be willing to pay $\overline{p}$ knowing that he has no interest in buying an additional unit of good in Period 2.

Proposition 2 formally presents this result. Recall that N^* equals $N - \underline{N}$, and $\overline{N}(c_I) = \frac{(1-2c_I)N+f}{1-c_I}$.

Proposition 2. *The game described above has the following pure-strategy subgame-perfect coalition-proof Nash equilibria, for any $R > 0$, $N \geq 2$, c_I, and f that satisfy (A1).*

1. *If $N^* \leq R < \overline{N}(c_I)$, the incumbent implements a rebate offer $(\overline{p}^*, \underline{p}^*)$ accepted by all recurrent customers so as to prevent Firm E from entering the market in period 2. In period 1, Firm I sets*

$\mathcal{M}^* = \big\{(1 + \delta(c_I - \kappa), \kappa); 1\big\}$, where $\kappa \in \big[0, \frac{1}{R}[f - (N - R)c_I]\big)$, all recurrent customers choose the rebate offer, while all occasional customers choose to pay the stand-alone price $p^*_{I1} = 1$. In period 2, Firm I charges $p^*_{I2} = 1$, all second-period customers buy from the incumbent and entry does not occur.

2. *Otherwise, the incumbent implements a partially exclusionary rebate scheme, as described in Proposition 1.*

Proof. See Appendix. □

Interpretation of the results Optimal rebates are characterized by the joint optimization of $\overline{p}$ and $\underline{p}$, which considerably reduces the cost of entry deterrence and entry accommodation because the particularly high first-period price balances the entry-deterrent low second-period price. This explains why entry deterrence and entry accommodation are possible even if the entrant's fixed cost is low.

Entry deterrence is more profitable than entry accommodation when Firm I's marginal cost is lower than a given threshold $\overline{c_I}$, which depends on the number of recurrent customers. The number of recurrent customers must be high enough to allow the incumbent to deter entry. However, when it increases, the incumbent grants a large number of standardized rebates: a significant share of second-period customers therefore pays the discounted price in period 2, and entry deterrence becomes less profitable. When $R = N^*$, entry deterrence is more profitable than entry accommodation if Firm I's marginal cost is below $\underline{N}/N$, which is the ratio of the minimum number of customers that the entrant must serve to profitably enter the market over the total number of customers. When $R = N^* + n$, for any integer $n \leq \underline{N} - 1$, this ratio equals $(\underline{N} - n)/(N - n)$.

There is a *set* of optimal entry-deterrent rebates. The incumbent is indeed indifferent between any $\overline{p}$ and $\underline{p}$ for which $\overline{p} + \delta\underline{p} = 1 + \delta c_I$, as long as these prices prevent Firm E from entering the market (i.e., $R\underline{p} + (N - R)c_I < f$).

Entry deterrence is possible even if there is customer miscoordination. In other words, customers do not have a joint interest in refusing the rebate offer in order to let Firm E enter the market.

The incumbent does not need to know *ex ante* each customer's type to profitably deter entry. Entry deterrence and entry accommodation are based on implicit discrimination amongst first-period customers, who self select de-

pending on their type. The optimal menu of prices is incentive compatible. Thus, knowing the type of each first-period customer and allowing for explicit discrimination would not increase the profit that the incumbent can achieve granting standardized rebates.

Entry deterrence occurs only if the value of the discount factor δ is strictly positive. If recurrent customers were perfectly myopic, they would behave as occasional customers and they would not accept the rebate in the first place. The value of the discount factor, as long as it is strictly positive, does not affect the incumbent's ability to accommodate entry or to prevent the efficient rival from entering the market. However, the higher the discount factor the larger the incumbent's benefit from entry deterrence or entry accommodation.

Firms frequently implement such rebate schemes. For instance, airlines or railway companies often propose costly loyalty cards in order to select recurrent customers. Some firms also offer to their largest retailers to be "official dealers." In such a case, the dealer has to pay an important lump-sum fee to the producer in order to benefit from significant rebates. The subscription business model, adopted in many industries, also consists in charging an initial fixed fee for a long-period access to the product or service at a very low (if not zero) price.

2.3 Discussion

This section discusses the conditions for successful entry deterrence. More precisely, I show that entry deterrence can also occur (i) when the incumbent does not discriminate (even implicitly) amongst first-period customers, and (ii) when it serves heterogenous recurrent customers only.

2.3.1 Non-discriminatory entry-deterrent loyalty rebates

Proposition 2 states that the *optimal* entry-deterrent pricing scheme is such that the first-period price is greater than a customer's willingness to pay ($\overline{p} > 1$). This high first-period price allows the incumbent to implicitly discriminate amongst first-period customers because only recurrent customers would be willing to accept it in exchange for a low second-period price. This simple pricing policy is currently implemented by firms that face both recurrent and occasional customers.

However, non-discriminatory loyalty rebates are also extremely common, and one may wonder whether entry deterrence is still possible when granting a rebate offer that can be accepted by all (recurrent and occasional) first-period customers – that is imposing $p_{I1} = \overline{p}$. In such a case, the incumbent no longer discriminates (even implicitly) amongst customers.

I show that, under certain conditions, the incumbent can deter entry granting non-discriminatory entry-deterrent loyalty rebates. Proposition 3 formally presents this result. Recall that N^* equals $N - \underline{N}$, and $\overline{N}(c_I) = \frac{(1-2c_I)N+f}{1-c_I}$.

Proposition 3. *Imposing $p_{I1} = \overline{p}$, the game described above has the following pure-strategy subgame-perfect coalition-proof Nash equilibria, for any $R > 0$, $N \geq 2$, c_I, and f that satisfy (A1).*

1. *If $N^* \leq R < \overline{N}(c_I)$, the incumbent can implement a rebate offer $(\overline{p}^*, \underline{p}^*)$ accepted by all recurrent customers so as to prevent Firm E from entering the market in period 2. In period 1, Firm I sets $\mathcal{M}^* = \left\{\left(1, \frac{1}{R}\left[f - (N-R)c_I\right] - \epsilon\right); 1\right\}$, for a strictly positive ϵ that tends to zero. All first-period customers choose the rebate offer. Firm I charges $p_{I2}^* = 1$ to second-period occasional customers, all second-period customers buy from the incumbent and entry does not occur.*

2. *Otherwise, the incumbent does not implement any non-discriminatory rebate offer in period 1, and sets* $p_{I1}^* = 1$. *In period 2, prices are given by* $p_{I2}^* = p_E^* = c_I$, *all second-period customers buy from the entrant,* $\Pi_E = Nc_I - f > 0$, *and entry occurs.*

Proof. See Appendix. □

All first-period customers choose the rebate offer. The incumbent can profitably deter entry because the reduced second-period price, which makes entry deterrence costly, is payed by recurrent customers only. The non-discrimination restriction ($p_{I1} = \overline{p}$) does not allow the incumbent to accommodate entry as it implies that the first-period profit equals the benchmark situation profit ($\tilde{\Pi}_{I1} = N(1 - c_I)$).

An important implication of Proposition 3 is that the incumbent no longer needs to implement a menu of prices. A single rebate offer $(\overline{p}, \underline{p})$ allows it to profitably deter entry. In other words, the menu $\mathcal{M}^* = \big\{(1, \kappa); 1\big\}$ is equivalent to the rebate offer $r^* = (1, \kappa)$.

It is much costlier for the incumbent to implement a non-discriminatory rebate scheme than an implicitly discriminatory one. Indeed, Firm I's profit when granting non-discriminatory rebates is $\Pi_I^{ND} = N(1-c_I)+\delta\big[(N-R)(1-c_I) + (f - Nc_I)\big]$ and $\Pi_I^* = N(1 - c_I) + \delta(N - R)(1 - c_I)$, when it implicitly discriminates amongst first-period customers. Hence, $\Pi_I^{ND} - \Pi_I^* = \delta(f - Nc_I)$, which is strictly negative. The first-period price of a non-discriminatory rebate is constrained and cannot balance the necessary low second-period discounted price.

2.3.2 Entry deterrence without occasional customers

The presence of *recurrent* and *occasional* customers is a particular – albeit common – demand structure. In this section, I first show that, absent any occasional customers, the incumbent can grant *individualized* rebates to deter entry. I then show that the pricing strategy described above can be profitably implemented in order to prevent an efficient rival from entering the market when the incumbent faces only recurrent customers with heterogeneous preferences. In such a case, customer heterogeneity stems from the quantity they purchase (and not whether they purchase or not in both periods, as in the previous section).

2.3.2.1 Optimal entry-deterrent individualized rebates

Individualized rebates allow Firm I to deter entry even though it only faces recurrent customers. n^* is the optimal number of rebates r^* that need to be implemented so as to deter entry. Let assume that (i) there are $R \in [N^*, N]$ recurrent customers, and (ii) $c_I < \overline{c_I} = \frac{N-n^*+f}{2N-n^*}$. Firm I can profitably deter entry by restricting the number of rebate offers $r^* = (\overline{p}^*, \underline{p}^*)$ as defined in Proposition 2 that it grants to $n^* \in [N^*, N)$. In period 1, n^* recurrent customers i therefore anticipates that Firm E has therefore no longer interest in entering the market and accept the rebate offer as $U^i(r^*) = \delta(1-c_I) = U^i(\tilde{p}_{I1}, \tilde{p}_{E2})$. The remaining $R-n^*$ recurrent customers j therefore accept Firm I's independent prices (p^*_{I1}, p^*_{I2}) because $U^j(p^*_{I1}, p^*_{I2}) = 0 = U^j(p^*_{I1}, p^*_{E2})$.

The incumbent's intertemporal profit $\Pi_I(n) = N(1-c_I) + \delta(N-n)(1-c_I)$ is decreasing in n. The incumbent therefore seeks to minimize the number of rebates it grants. The optimal number of entry-deterrent individualized rebate offers is thus $n^* = N^*$.

2.3.2.2 Recurrent customer heterogeneity

I now consider recurrent customers only, whose heterogeneity comes from the quantity they purchase in each period. This implies slight changes in the basic model presented in Section 2.2.

The incumbent faces L large customers (or retailers), purchasing a quantity q^l in both periods, and $N - L$ small customers, who buy a quantity q^s in each period, such that $q^s < q^l$. The total quantity purchased by all large customers, Lq^l, is denoted Q^l. Similarly, the total quantity purchased by all small customers, $(N-L)q^s$, is denoted Q^s. The type of the customer (*large* or *small*) is private information. Firm E's fixed entry cost is strictly positive. It can therefore be written as:

$$\underline{Q}c_I = f < Qc_I, \tag{A1'}$$

where $\underline{Q} > 0$, and Q is the total demand ($Q = Q^l + Q^s = Lq^l + (N-L)q^s$).

I show that the incumbent can grant entry-deterrent standardized rebates defined by the menu of $\mathcal{M}^* = \left\{(\overline{p}, \underline{p}); p_{I1}\right\}$, where $\overline{p}$ and $\underline{p}$ are first- and second-period unit prices charged to a customer who accepts to buy q^l units in period 1 (the rebate offer does not impose the purchase of a minimum quantity of good in period 2), and p_{I1} is the unit price charged to the customer who purchases a quantity q^s.

Independent pricing The independent price benchmark is the same as in Section 2.2.2: during the first period, the incumbent sets $\tilde{p}_{I1} = 1$ to each first-period customer. It gets a first-period profit $\tilde{\Pi}_{I1} = Q(1 - c_I)$. In the second period, Firm E decides to enter the market. Both firms simultaneously set $\tilde{p}_E = \tilde{p}_{I2} = c_I$, Firm E serves all second-period customers, and makes a profit

$\tilde{\Pi}_E = Qc_I - f > 0$.

Entry accommodation and entry deterrence Entry deterrence is more profitable than entry accommodation as long as (i) c_I is lower than a given threshold,[12] and (ii) $Q^s < \underline{Q}$. The following two situations can be distinguished: (i) when q^l is significantly larger than q^s, the incumbent can design an incentive-compatible mechanism such that each first-period customer truthfully reveals its type. This case is the same as in Section 2.2.4. (ii) When q^l is close to q^s, small customers have an interest in pretending to be of the large type. They thus decide to buy more than they would do absent any rebate scheme in period 1 in exchange for a very low price in period 2; in this case, all first-period customers accept the rebate offer.

Proposition 4 formally presents this result. In Proposition 4 below, $\overline{Q}(c_I) = \frac{Q-\underline{Q}}{1-c_I}c_I$, $\tilde{Q}(c_I) = (N-L)q^l - \frac{\delta(Q^l-Q)c_I}{1-c_I+\delta c_I}$ and $\underline{\Psi} = \frac{(1+\delta c_I)q^l-(1+\delta)q^s}{\delta(q^l-q^s)}$.

Proposition 4. *The game described above has the following pure-strategy coalition-proof Nash equilibria, for $q^l > q^s > 0$, $L > 1$, and for c_I, and f that satisfy (A1').*

1. *Entry deterrence:*

   (a) *If $q^l > \frac{1+\delta}{1+\delta c_I}q^s$, and $\underline{Q} > Q^s > \overline{Q}(c_I)$, Firm I sets $\mathcal{M}^* = \{\big(1+\delta(c_I-\kappa),\kappa\big),1\}$, where $\kappa \in \Big[0, \min\Big\{\frac{1}{Q^l}(f-Q^s c_I), \underline{\Psi}\Big\}\Big)$, large customers accept the rebate offer, while small ones pay the stand-alone price $p^*_{I1} = 1$. In period 2, firms set $p^*_{I2} = p^*_E = 1$, all second-period customers buy from the incumbent and entry does not occur (Implicit discrimination – separating equilibrium).*

   (b) *If $q^l < \frac{1+\delta}{1+\delta c_I}q^s$, and $Q^s < \min\{\underline{Q}, \tilde{Q}(c_I)\}$, Firm I sets $\mathcal{M}^* = \{\big(1+\delta c_I, 0\big); 1\}$ in period 1, and all customers choose the rebate offer and purchase q^l. In period 2, large customers purchase q^l and small*

[12] This condition is given by $Q^s > \overline{Q}(c_I)$ and $Q^s < \tilde{Q}(c_I)$, in Proposition 4 below.

customers q^s, and entry does not occur (No discrimination – pooling equilibrium).

2. *Entry accommodation:*

   (a) *If $Q^s > \underline{Q}$, Firm I sets $\mathcal{M}^* = \{(1+\delta(c_I-\kappa),\kappa);1\}$, where $\kappa = \frac{1}{Q^l}[f-Q^s c_I]$. Firm I's profit is given by $\Pi_I^{EA} = Q(1-c_I) + \delta\rho_E$, where $\rho_E = Qc_I - f$ is Firm E's rent. In period 2, Firm E decides to enter, and makes no profit: $\Pi_E^{EA} = 0$.*

   (b) *Otherwise, Firm I sets $\mathcal{M}^* = \{(1+\delta(c_I-\epsilon),\epsilon);1\}$, where ϵ is strictly positive and tends to 0. In period 1, all recurrent customers choose the rebate offer, while all occasional customers choose to pay the stand-alone price $p_{I1}^* = 1$. Firm I's profit is $\Pi_I^{EA} \approx Q(1-c_I) + \delta Q^l c_I$. In period 2, Firm E decides to enter, and makes a profit $\Pi_E^{EA} \approx Q^s c_I - f$.*

Proof. See Appendix. □

Proposition 4 shows the incumbent can implement an entry-deterrent standardized rebate offer when facing only recurrent customers with different demand functions.

The main difference with the situation where the incumbent faces occasional and recurrent customers is the existence of "buyer opportunism." At equilibrium, the rebate offer can induce small customers to purchase unneeded units of the good from the incumbent. This additional first-period revenue allows the incumbent to finance its exclusionary strategy. This strategy leads to a pooling equilibrium: when the quantity demanded by small customers (q^s) is close enough to the quantity purchased by large customers (q^l), the incumbent cannot implement a rebate offer that allows it to select large customers only. In such a case, small customers are better off pretending to be of the *large* type. This equilibrium strategy is of particular interest as

it is characterized by the foreclosure of the entire second-period demand. The rebate offer is not (even implicitly) discriminatory and the menu of prices is equivalent to a single rebate offer. Furthermore, all customers pay the same price in each period. Such a strategy is profitable for the incumbent simply because the rebate offer makes small customers purchase a quantity of good in period 1 larger than they would be willing to buy when paying the stand-alone unit prices (q^l instead of q^s). This rebate offer is accepted by small customers because the difference between the quantity q^l that allows a customer to benefit from the rebate and the quantity q^s that small customers would like to purchase is not too significant. Interestingly, this quantity effect, which makes entry deterrence profitable, is one of the reasons why rebates are considered pro-competitive in most US antitrust cases.[13]

The following example illustrates Proposition 4.

- Let $\delta = 1$, $N = 100$, $\underline{Q} = 32$, $L = 50$, $q^l = 1$, $q^s = .5$ and $c_I = .25$. Hence, $q^l > \frac{1+\delta}{1+\delta c_I} q^s = .8$, $Q^s = 25 < \underline{Q}$ and $Q^s > \overline{Q}(c_I) = 43/3 \approx 14.3$. Therefore, it is optimal for the incumbent to set e.g. $\mathcal{M}^* = \big\{(1.25, 0); 1\big\}$. Only large customers accept the rebate offer and $\mathcal{M}^*$ allows the incumbent to profitably deter entry.

- Consider now a smaller difference between q^l and q^s, e.g. $q^l = .9$ and $q^s = .6$ (instead of 1 and .5). In such a case, a small customer is better off pretending to be of the large type and purchasing a quantity $q^l = .9$ in period 1 to benefit from the rebate offer. Indeed, $q^l < \frac{1+\delta}{1+\delta c_I} q^s = .96$, $Q^s < \underline{Q}$ and $Q^s < \tilde{Q}(c_I) = 41.75$. Therefore, it is optimal for the incumbent to grant a rebate $r^* = (1.25, 0)$, which is accepted by all first-period customers to profitably deter entry.

[13] See e.g. Concord Boat Corp. v. Brunswick Corp., 207 F.3d 1039 (8th Cir. 2000).

2.4 Conclusion

Loyalty rebates are particularly effective entry deterrent strategies when customers' preferences are heterogeneous.

This paper shows that, when demand is heterogeneous, optimal entry-deterrent loyalty rebates consist in charging a first-period list price that is particularly high and committing to a significantly reduced price on future sales. This pricing scheme induces customers to select themselves according to their type, thereby denying the rival scale. Such a mechanism diametrically differs from other exclusionary contracts and pricing schemes, which consist in charging an aggressive first-period prices to deter entry before enjoying a leveraged dominant position in subsequent periods.

Moreover, implicit discrimination is neither always necessary nor possible. The incumbent can grant non-discriminatory loyalty rebates when demand heterogeneity is not important enough to design an incentive-compatible mechanism. In such a case, the rebate may induce customers who are not *ex ante* eligible for the discount to behave so as to benefit from it. For instance, a rebate can give incentives to small customers to purchase as much as large customers do, thereby making entry deterrence profitable.

Appendix

Proof of Proposition 1

Let suppose that $n > 0$ recurrent buyers accepted the rebate offer during the first period. If there is entry in period 2, Firm E sets prices that undercut Firm I's, i.e., $p_E^i = \underline{p}$ to the n customers i who accepted the rebate offer and $p_E^j = p_{I2} = c_I$ to the $N-n$ customers j who did not. Firm E enters if and only if $n\underline{p} + (N-n)c_I \geq f$ – which defines the entry-accommodation condition. Furthermore, Firm E serves in Period 2 a customer who accepted the rebate in Period 1, if $\overline{p} > 0$.

In period 1, a recurrent customer accepts the rebate r if and only if (i) he is better off accepting the rebate offer than paying stand-alone prices in both periods (p_{I1} and p_{I2}); and (ii) he is better off buying one unit during the first period than refusing to buy it, thereby allowing Firm E to enter the market.[14]

Both recurrent customers' participation constraints can be written as

$$(1-\overline{p}) + \delta(1-\underline{p}) \geq (1-p_{I1}) + \delta(1-p_E), \tag{2.1}$$

$$(1-\overline{p}) + \delta(1-\underline{p}) \geq \delta(1-c_I). \tag{2.2}$$

Conditions (2.1) implies (2.2), since $p_{I1} \leq 1$ and $p_E = c_I$. Recurrent customers' participation constraint is therefore given by:

$$\overline{p} + \delta\underline{p} \leq p_{I1} + \delta c_I. \tag{PC}$$

[14]In order to rule out miscoordination equilibria, I consider that each recurrent customer is pivotal, meaning that all other customers behave in the same way. This indeed ensures that all recurrent customers have an interest in jointly accepting the rebate offer. Since the occasional customers are not interested in future units, these constraints are necessary to ensure that the equilibrium solutions derived from the maximization program defined below define coalition-proof Nash equilibria. Indeed, there would be entry-deterrence because of customers' miscoordination if, e.g., a number of recurrent customers high enough to deter entry would accept the rebate offer such that $1 + \delta c_I < \overline{p} + \delta\underline{p} \leq 1 + \delta$.

Firm I maximization program is given by

$$\begin{aligned}\max_{\overline{p},\underline{p},p_{I1}} \big\{\Pi_I^{EA} \quad &= n(\overline{p}-c_I)+(N-n)(p_{I1}-c_I)\big\},\\ \text{s.t.} \qquad & n\underline{p}+(N-n)c_I \geq f,\\ & \overline{p}+\delta\underline{p} \leq p_{I1}+\delta c_I,\\ & \overline{p}>0, \quad p_{I1},\underline{p}\in[0,1].\end{aligned}$$

Firm I seeks to maximize $\overline{p}$, which implies that $p_{I1}=1$, and (PC) is binding. Therefore,

$$\underline{p} \geq \frac{1}{n}[f-(N-n)c_I]$$

As $\underline{p}$ must be strictly larger than 0, two cases must be distinguished.

Case 1 $\frac{1}{n}[f-(N-n)c_I] \leq 0$: Firm I sets $\underline{p}=\epsilon$, where ϵ is strictly positive and tends to 0. $\frac{1}{n}[f-(N-n)c_I] \leq 0$ implies that $(N-n)c_I \geq f$. Therefore, from (A1), $(\underline{N}+1)c_I \geq (N-n)c_I$, which implies $n<N^*=N-\underline{N}$.

In such a case, $\mathcal{M}^* = \big\{(1+\delta(c_I-\epsilon),\epsilon);1\big\}$. Only recurrent customers choose the rebate offer, as $\overline{p}=1+\delta(c_I-\epsilon)>1$. Therefore, $n=R$. Firm I's profit is

$$\begin{aligned}\Pi_I^{EA} &= R(1+\delta c_I-\delta\epsilon-c_I)+(N-R)(1-c_I),\\ \Pi_I^{EA} &\approx N(1-c_I)+\delta R c_I,\end{aligned}$$

which is larger than $\tilde{\Pi}_I$, as $\delta>0$. Firm E's profit is

$$\begin{aligned}\Pi_I^{EA} &= R\epsilon+(N-R)c_I-f,\\ \Pi_E^{EA} &\approx (N-R)c_I-f,\end{aligned}$$

which is strictly positive because $R = n \in (0, N^*)$.

Case 2 $\frac{1}{n}[f - (N-n)c_I] > 0$: Firm I sets $\underline{p} = \frac{1}{n}[f - (N-n)c_I]$. $\frac{1}{n}[f - (N-n)c_I] > 0$ implies that $(N-n)c_I > f$. Therefore, from (A1), $n \geq N^* = N - \underline{N}$. Furthermore, $\underline{p} = \frac{1}{n}[f - (N-n)c_I] < c_I$ because $Nc_I > f$. This implies $\overline{p} > 1$, hence $n = R$.

In such a case, $\mathcal{M}^* = \big\{(1 + \delta(c_I - \kappa), \kappa); 1\big\}$, where $\kappa = \frac{1}{R}[f - (N-R)c_I]$. Firm I's profit is

$$\Pi_I^{EA} = R\Big[1 + \delta c_I - \frac{\delta}{R}\big[f - (N-R)c_I)\big] - c_I\Big],$$
$$\Pi_I^{EA} = N(1 - c_I) + \delta(Nc_I - f) = \tilde{\Pi}_I + \delta\rho_E,$$

where ρ_E is Firm E's rent. Firm E's profit equals 0.

Proof of Proposition 2

Let suppose that $n > 0$ recurrent buyers accepted the rebate offer during the first period. The following no-entry condition provides the maximum second-period prices that Firm I can set in order to deter entry.

$$n\underline{p} + (N-n)c_I < f. \qquad \text{(NEC)}$$

The participation constraint (PC) is the same as before.

Firm I's maximization program is given by

$$\max_{\overline{p},\underline{p},p_{I1},p_{I2}} \big\{\Pi_I = n(\overline{p} - c_I) + (N-n)(p_{I1} - c_I) + \delta[n(\underline{p} - c_I) + (N-n)(p_{I2} - c_I)]\big\},$$
$$\text{s.t.} \quad n\underline{p} + (N-n)c_I < f,$$
$$\overline{p} + \delta\underline{p} \leq p_{I1} + \delta c_I,$$
$$\overline{p} \geq 0, \quad p_{I1}, p_{I2}, \underline{p} \in [0, 1].$$

Π_I increases with stand-alone prices (p_{I1} and p_{I2}), which are not constrained: $p^*_{I1} = p^*_{I2} = 1$. Π_I also increases with $\overline{p} + \delta\underline{p}$, the participation constraint is thus binding: $\overline{p} + \delta\underline{p} = 1 + \delta c_I$. Finally, the no-entry condition implies $\underline{p} < c_I$, since $f > Nc_I$: if $\underline{p} \geq c_I$, $n\underline{p} + (N-n)c_I \geq Nc_I > f$, which would contradict the NEC. Hence, $\overline{p} > 1$. This ensures that the solutions to the maximization problem is incentive-compatible. Indeed, the menu of prices $\mathcal{M} = \{(\overline{p}, \underline{p}); p_{I1}\}$ is incentive compatible if (i) an occasional customer has no interest in pretending to be a recurrent one; and (ii) a recurrent customer has no interest in pretending to be an occasional one. This implies $\overline{p} \geq p_{I1}$ and $\overline{p} + \delta\underline{p} \leq p_{I1} + \delta p_{I2}$. If the participation and incentive-compatibility constraints are satisfied, $n = R$ since the R recurrent customers accept the rebate offer and the $N - R$ occasional ones decide to pay the stand-alone price p_{I1}.

Rearranging the terms, the maximization problem is given by

$$\begin{aligned} \max_{\overline{p},\underline{p},p_{I1}} \big\{\Pi_I \quad &= n(\overline{p} + \delta\underline{p}) - n(1+\delta)c_I + (1+\delta)(N-n)(1-c_I)\big\}, \\ \text{s.t.} \qquad & 0 \leq \underline{p} < \tfrac{1}{n}\big[f - (N-n)c_I\big], \quad \underline{p} < c_I, \\ & \overline{p} + \delta\underline{p} = 1 + \delta c_I. \end{aligned}$$

Note that $\frac{1}{n}[f-(N-n)c_I] < c_I$ because Firm E's efficiency implies $Nc_I - f > 0$. The set of optimal rebate offers is therefore given by $\overline{p}^* = 1 + \delta(c_I - \kappa)$, $\underline{p}^* = \kappa$, where $\kappa \in \big[0, \frac{1}{n}[f - (N-n)c_I]\big)$.

Such rebate offers can be implemented if and only if $\frac{1}{n}[f - (N-n)c_I] > 0$, i.e, $f > (N-n)c_I$, that is $n \geq N - \underline{N} = N^*$.

Finally, this entry-deterrent strategy must be more profitable than entry accommodation (which is always more profitable than independent pricing,

as Proposition 1 shows), i.e., $\Delta\Pi = \Pi_I^* - \Pi_I^{EA} > 0$, that is

$$\begin{aligned}\Delta\Pi &= N(1-c_I) + \delta(N-R)(1-c_I) - N(1-c_I) - \delta(Nc_I - f) \\ \Delta\Pi &= \delta[(N-R)(1-c_I) - (Nc_I - f)].\end{aligned}$$

As $\delta > 0$, $\Delta\Pi > 0$ if and only if $R < \overline{N}(c_I) = \frac{(1-2c_I)N+f}{1-c_I}$, which is equivalent to $c_I < \overline{c_I} = \frac{N-R+f}{2N-R}$. If $R = N$, $c_I < \overline{c_I}$ implies $c_I < \frac{f}{N}$, which contradicts (A1).

Proof of Proposition 3

The non-discrimination restriction $\overline{p} = p_{I1}$ implies the following participation constraints: $\overline{p} \leq 1$ and $\underline{p} \leq c_I$. It also implies that all first-period customers choose the rebate offer. In period 1, N customers accepts the rebate offer. In period 2, all recurrent customers pays $\underline{p}$ and all occasional customers pays $p_{I2} = 1$. Finally, such a restriction prevents Firm I from accommodating entry. Firm I's maximization program is given by

$$\begin{aligned}\max_{\overline{p},\underline{p}} \big\{\Pi_I &= N(\overline{p} - c_I) + \delta[R(\underline{p} - c_I) + (N-R)(1-c_I)]\big\}, \\ \text{s.t.} \qquad & R\underline{p} + (N-R)c_I < f, \\ & 0 \leq \underline{p} \leq c_I, \quad \overline{p} \in [0,1].\end{aligned}$$

Therefore , $\overline{p}^* = 1$, and the incumbent charges the maximum $\underline{p}$ such that the NEC is satisfied: $\underline{p}^* = \frac{1}{R}\big[f - (N-R)c_I\big] - \epsilon$, where ϵ is strictly positive and tends to zero. Such rebate offers are implementable if and only if $\frac{1}{R}[f - (N-R)c_I] > 0$, i.e, $R \geq N - \underline{N} = N^*$.

Finally, such an entry-deterrent strategy must be more profitable than in-

dependent pricing, i.e., $\Delta\Pi = \Pi_I^* - (\tilde{\Pi}_{I1} + \tilde{\Pi}_{I2}) > 0$, where

$$\begin{aligned}\Pi_I^* &= N(1-c_I) + \delta\big[f - (N-R)c_I - Rc_I - R\epsilon + (N-R)(1-c_I)\big], \\ &\approx N(1-c_I) + \delta(N-R)(1-c_I) + \delta(f - Nc_I).\end{aligned}$$

$\Delta\Pi = \delta(N-R)(1-c_I) + \delta(f-Nc_I) > 0$ if and only if $R < \overline{N}(c_I) = \frac{(1-2c_I)N+f}{1-c_I}$, which is equivalent to $c_I < \overline{c_I} = \frac{N-R+f}{2N-R}$. If $R = N$, $c_I < \overline{c_I}$ implies $c_I < \frac{f}{N}$, which contradicts (A1).

Proof of Proposition 4

Entry accommodation

n = L Firm I maximizes its profit

$$\Pi_{I,n=L}^{EA} = Q^l(\overline{p} - c_I) + Q^s(p_{I1} - c_I)$$

subject to the entry accommodation condition (EAC) $Q^l\underline{p} + Q^s c_I \geq f$, the participation constraint (PC) $\overline{p} + \delta\underline{p} \leq p_{I1} + \delta c_I$, and an incentive compatibility condition (IC) that ensures that small customers have no interest in pretending of being of the large type: $q^l\overline{p} + \delta q^s\underline{p} \geq q^s(p_{I1} + \delta c_I)$. Rearranging these last two constraints gives $q^l\overline{p} \geq q^s(p_{I1} + \delta c_I - \delta\underline{p}) \geq q^s\overline{p}$. For any $\overline{p} > 0$, $q^l\overline{p} \geq q^s\overline{p}$. Therefore, when (PC) is binding, (IC) is satisfied (hence $n = L$). Finally, conditions on prices are given by: $\overline{p}, \underline{p} > 0$, and $p_{I1} \in [0,1]$.

Firm I seeks to maximize $\overline{p}$, which implies that $p_{I1} = 1$, and (PC) is binding. Hence,

$$\underline{p} \geq \frac{1}{Q^l}(f - Q^s c_I) = \frac{1}{Q^l}(\underline{Q} - Q^s)c_I$$

As $\underline{p}$ must be strictly larger than 0, two cases must be distinguished.

Case 1: $(\underline{Q} - Q^s)c_I/Q^l \leq 0$, i.e., $Q^s \geq \underline{Q}$, Firm I sets $\overline{p} = 1 + \delta(c_I - \epsilon)$, $\underline{p} = \epsilon$, where ϵ is strictly positive and tends to 0. Firm I's profit is given by $\Pi^{EA}_{I,n=L} \approx Q(1 - c_I) + \delta Q^l c_I$, which is larger than $\tilde{\Pi}_I$, as $\delta > 0$. Firm E's profit is given by $\Pi^{EA}_E \approx (Q^s - \underline{Q})c_I$, which is strictly positive because $Q^s > \underline{Q}$.

Case 2: $(\underline{Q} - Q^s)c_I/Q^l > 0$, i.e., $Q^s < \underline{Q}$, Firm I sets $\overline{p} = 1 + \delta(c_I - \kappa)$, $\underline{p} = \kappa$, where $\kappa = (\underline{Q} - Q^s)c_I/Q^l$. Firm I's profit is given by $\Pi^{EA}_{I,n=L} = Q(1-c_I) + \delta(Q - \underline{Q})c_I$, which is larger than $\tilde{\Pi}_I$, as $\delta > 0$. Firm E's profit equals 0.

n = N Firm I maximizes its profit

$$\Pi^{EA}_{I,n=N} = Nq^l(\overline{p} - c_I)$$

subject to the entry accommodation condition (EAC) $Q^l\underline{p} + Q^s c_I \geq f$, the participation constraint (PC) $\overline{p} + \delta\underline{p} \leq p_{I1} + \delta c_I$, and an incentive compatibility condition (IC) that ensures that small customers have an interest in pretending of being of the large type: $q^l\overline{p} + \delta q^s\underline{p} < q^s(p_{I1} + \delta c_I)$. (IC) implies (PC), and the last two constraints can be rewritten as $q^l\overline{p} < q^s(1 + \delta c_I - \delta\underline{p})$. Finally, conditions on prices are given by: $\overline{p}, \underline{p} > 0$, and $p_{I1} \in [0, 1]$.

Firm I therefore sets $\underline{p} = f/Q$, $\overline{p} = \frac{q^s}{q^l}[1 + \delta(c_I - f/Q)] - \epsilon$, , where ϵ is strictly positive and tends to 0. Firm I's profit is given by $\Pi^{EA}_{I,n=N} \approx Nq^s\big(1 + \delta\frac{Q-\underline{Q}}{Q}c_I\big) - Nq^l c_I$.

When $Q^s \geq \underline{Q}$,

$$\begin{aligned}\Pi^{EA}_{I,n=N} &\approx Nq^s\big(1+\delta\frac{Q-\underline{Q}}{Q}c_I\big) - Nq^l c_I,\\ &< Nq^s - Nq^l c_I + \delta N q^s c_I,\\ &< Q(1-c_I) + \delta Q^l c_I = \Pi^{EA}_{I,n=L}.\end{aligned}$$

When $Q^s < \underline{Q}$,

$$\begin{aligned}\Pi^{EA}_{I,n=N} &\approx Nq^s\big(1-\delta\frac{Q-\underline{Q}}{Q}c_I\big) - Nq^l c_I,\\ &< Q - Nq^l c_I + \delta(Q-\underline{Q})c_I,\\ &< Q(1-c_I) + \delta(Q-\underline{Q})c_I = \Pi^{EA}_{I,n=L}.\end{aligned}$$

When accommodating entry, the incumbent has no interest in designing a rebate offer that induces small customers to purchase a quantity q^l as if they were of the large type.

Entry deterrence

n = L Only large customers have an interest in choosing the rebate offer. Small customers have no interest in purchasing a quantity q^l and benefit from the loyalty rebate. Firm I maximizes its profit

$$\Pi_{I,n=L} = Q^l(\overline{p} - c_I) + Q^s(p_{I1} - c_I) + \delta[Q^l(\underline{p} - c_I) + Q^s(p_{I2} - c_I)],$$

where $\underline{p}, \overline{p} \geq 0$, and $p_{I1}, p_{I2} \in [0,1]$, subject to the NEC

$$Q^l\underline{p} + Q^s c_I < f,$$

and large customers' and small customers' incentive compatibility constraints, which are given by

$$\overline{p} + \delta \underline{p} \leq p_{I1} + \delta c_I, \tag{ICl}$$

$$p_{I1} \leq 1 \tag{PCl}$$

$$q^l \overline{p} + \delta q^s \underline{p} > q^s (p_{I1} + \delta p_{I2}). \tag{ICs}$$

$$p_{I1} \leq 1, \quad p_{I2} \leq 1 \tag{PCs}$$

These constraints ensure that the equilibrium solutions derived from aforementioned maximization program are coalition-proof Nash equilibria, since any coalition of small customers only cannot makes entry occurs by refusing the rebate and large customers have no interest in participating to a coalition with small customers so as order to allow Firm E to enter the market. Coalitions gathering small and large customers are not self-enforcing. Firm I does not commit in period 1 on a given second-period stand-alone price. If there is no entry, $p_{I2}^* = 1$. Large customers' participation constraint is binding: $\delta \underline{p} = p_{I1} - \overline{p} + \delta c_I$. Therefore, small customers' incentive compatibility constraint is satisfied only if

$$\overline{p} > \frac{\delta q^s (1 - c_I)}{q^l - q^s}.$$

Hence, $p_{I1}^* = 1$, and

$$\underline{p} < \frac{(1 + \delta c_I) q^l - (1 + \delta) q^s}{\delta (q^l - q^s)} = \underline{\Psi}.$$

The maximization program can therefore be rewritten as

$$\begin{aligned}\max_{\underline{p}} \big\{\Pi_I \quad &= Q^l(\overline{p}+\delta\underline{p}) - (1+\delta)Q^l c_I + (1+\delta)Q^s(1-c_I)\big\},\\ \text{s.t.} \qquad & \underline{p} < c_I,\\ & 0 \le \underline{p} < \tfrac{1}{Q^l}(f - Q^s c_I),\\ & 0 \le \underline{p} < \underline{\Psi},\\ & \overline{p} + \delta\underline{p} = 1 + \delta c_I.\end{aligned}$$

Since $f < Qc_I$, $\frac{1}{Q^l}(f - Q^s c_I) < c_I$. The set of optimal rebate offers is therefore given by

$$r^*_{n=L} = \big(1 + \delta(c_I - \kappa), \kappa\big),$$

where

$$\kappa \in \Big[0, \min\Big\{\frac{1}{Q^l}(f - Q^s c_I), \underline{\Psi}\Big\}\Big).$$

Such rebate offers can be implemented if $\frac{1}{Q^l}(f - Q^s c_I) > 0$, i.e., $\underline{Q} > Q^s$, and if $\underline{\Psi} > 0$, i.e.,

$$q^l > \frac{1+\delta}{1+\delta c_I} q^s.$$

Entry deterrence is more profitable than entry accommodation when

$$\begin{aligned}\Pi^*_{I,n=L} = \big[Q^l + (N-L)(1+\delta)q^s\big](1-c_I) &= (Q + \delta Q^s)(1-c_I)\\ &> Q(1-c_I) + \delta(Q - \underline{Q})c_I \approx \Pi^{EA}_I.\end{aligned}$$

that is $Q^s > \overline{Q}(c_I) = \frac{Q-\underline{Q}}{1-c_I} c_I$, which is equivalent to $c_I < \overline{c_I} = \frac{Q^s}{Q+Q^s-\underline{Q}}$.

n = N All customers, even the small ones, choose to purchase q^l in each period and pay the list and reduced prices of the rebate offer. A necessary condition is that small customers are not pivotal. If they were pivotal, they

would refuse the rebate offer to let Firm E enter and benefit from competition in period 2. The NEC is thus the same as in the case where $n = L$. The incumbent does not charge stand-alone prices, and maximizes its profit

$$\Pi_{I,n=N} = Nq^l(\overline{p} - c_I) + \delta Q(\underline{p} - c_I)$$

subject to the NEC and large customers' and small customers' participation constraints:

$$\begin{aligned} \overline{p} + \delta\underline{p} &\leq 1 + \delta c_I \quad \text{(PCl)} \\ q^l\overline{p} + \delta q^s\underline{p} &< q^s(1+\delta) \quad \text{(PCs)} \end{aligned}$$

Two situations can be distinguished.

(α) PCl is binding ($\overline{p} = 1 + \delta(c_I - \underline{p})$) and PCs is always satisfied if $\underline{p} > \underline{\Psi}$.

Firm I's maximization program is thus given by

$$\begin{aligned} \max_{\underline{p}} \left\{\Pi_{I,n=N}\right. &= \delta(Q - Nq^l)\underline{p} + Nq^l(1 + \delta c_I) - (Nq^l + \delta Q)c_I\Big\}, \\ \text{s.t.} \qquad & 0 \leq \underline{p} < \tfrac{1}{Q^l}(f - Q^s c_I), \\ & \underline{p} > \underline{\Psi}. \end{aligned}$$

Since $\Pi_{I,n=N}$ is decreasing with $\underline{p}$, Firm I seeks to minimize $\underline{p}$. Since $f > Q^s c_I$, two subcases can be distinguished.

(α_1) $\underline{\Psi} < 0$, i.e.,

$$q^l < \frac{1+\delta}{1+\delta c_I} q^s,$$

The optimal set of rebate offers is therefore given by

$$r^*_{\alpha_1} = \big(1 + \delta c_I, 0\big).$$

Firm I implements such an entry-deterrent rebate:

$$\begin{aligned}\Pi^*_{I,n=N}(r^*_{\alpha_1}) &= Nq^l(1-c_I) + \delta(Nq^l - Q)c_I \\ &> Q(1-c_I) + \delta(Q - \underline{Q})c_I \approx \Pi^{EA}_I,\end{aligned}$$

that is $Q^s < \tilde{Q}(c_I) = (N-L)q^l - \frac{\delta(Q^l-\underline{Q})c_I}{1-c_I+\delta c_I}$, i.e., $c_I < \tilde{c_I} = \frac{Nq^l-Q}{(1-\delta)Nq^l+(2\delta-1)Q-\delta\underline{Q}}$.

(α_2) $\frac{1}{Q^l}(f - Q^s c_I) > \underline{\Psi}$. The optimal set of rebate offers is therefore given by

$$r^*_{\alpha} = \big(1 + \delta(c_I - \underline{\Psi}), \underline{\Psi}\big) = (\overline{\Psi}, \underline{\Psi}),$$

where $\overline{\Psi} = \frac{\delta(1-c_I)q^s}{q^l-q^s}$, and $\underline{\Psi} = \frac{(1+\delta c_I)q^l-(1+\delta)q^s}{\delta(q^l-q^s)}$. The conditions of implementation of $r^*_{\alpha_2}$ and $r^*_{N=L}$ are the same, Firm I chooses to grant $r^*_{\alpha_2}$ to all first-period customers instead of $r^*_{N=L}$ if and only if $\Pi^*_{I,n=N}(r^*_{\alpha_2}) > \Pi^*_{I,n=L}$.

$$\begin{aligned}\Pi^*_{I,n=N}(r^*_{\alpha_2}) &= Nq^l(\overline{\Psi} - c_I) + \delta Q(\underline{\Psi} - c_I), \\ &= Nq^l\frac{\delta(1-c_I)q^s}{q^l-q^s} + Q\frac{(1+\delta c_I)q^l-(1+\delta)q^s}{q^l-q^s} \\ &\quad -(Nq^l + \delta Q)c_I, \\ &= \frac{Q}{q^l-q^s}\big[\delta(1-c_I)q^s + (1+\delta c_I)q^l - (1-\delta)q^s\big] \\ &\quad +\frac{(N-L)(q^l-q^s)\delta(1-c_I)q^s}{q^l-q^s} - (Nq^l+\delta Q)c_I, \\ &= Q + \delta Q^s(1-c_I) - (Nq^l + \delta Q)c_I, \\ &= (Q + \delta Q^s)(1-c_I) - (Nq^l - Q + \delta Q)c_I, \\ &< (Q + \delta Q^s)(1-c_I) = \Pi^*_{I,n=L},\end{aligned}$$

because $Nq^l > Q$. Firm I therefore never implements $r^*_{\alpha_2}$.

(β) PCs is binding and PCl is always satisfied if $\underline{p} < \underline{\Psi}$. The optimal set of rebate offers is therefore given by

$$r^*_\beta = \Big(\frac{q^s}{q^l}[1+\delta(1-\kappa)], \kappa\Big)$$

where

$$\kappa \in \Big[0, \min\Big\{\frac{1}{Q^l}(f - Q^s c_I), \underline{\Psi}\Big\}\Big)$$

$f > Q^s c_I$: the incumbent can implement this entry-deterrent rebate offer if and only if

$$q^l > \frac{1+\delta}{1+\delta c_I} q^s. \tag{2.3}$$

$\Pi^*_{I,n=N}(r^*_\beta) = Nq^s(1+\delta) - (Nq^l + \delta Q)c_I$. Since the conditions of implementation of r^*_β and $r^*_{N=L}$ are the same, Firm I chooses to grant $r^*_{N=L}$ instead of r^*_β if and only if $\Pi^*_{I,n=L} > \Pi^*_{I,n=N}(r^*_\beta)$.

$$\begin{aligned}\Pi^*_{I,n=L} - \Pi^*_{I,n=N}(r^*_\beta) = &\quad (Q+\delta Q^s)(1-c_I) - Nq^s(1+\delta) - (Nq^l+\delta Q)c_I,\\ = &\quad L\big[q^l(1+\delta c_I) - q^s(1+\delta)\big] + (N-L)(q^l - q^s)c_I,\end{aligned}$$

which is strictly positive since $q^l > \frac{1+\delta}{1+\delta c_I} q^s$. Firm I therefore never implements r^*_β.

Pages 89-136 (Chapter 3) have been removed from the TDX file at the request of the author.

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