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Cartels as Shock Absorbers: Collusion Dynamics in Times of Macroeconomic Instability

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Abstract

This paper investigates how business cycles and interest rate fluctuations affect cartel dynamics. To do so, we apply a Hidden Markov Model to a unique dataset on a population of (legal) cartels in Sweden, from 1947 to 1993. We find that GDP shocks and higher interest rates, as a proxy for borrowing costs, increase cartel formation and reduce cartel dissolution, with stronger effects in the manufacturing sector. Thus, GDP shocks and higher interest rates lead to an increase in the number of cartels in the economy. These findings highlight how cartels act as shock absorbers, helping firms handle economic instability and reducing the impact of both positive and negative shocks.

Keywords: Cartels, Legal contracts, Competition policy, Antitrust, Business cycles, Interest rates
JEL codes: D43, K21, L12, L13, L41, L60

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1 Introduction

In the current geopolitical and uncertain economic climate, concerns about anti-competitive behavior and macroeconomic uncertainty are growing. Weaker competitive pressures and the increasing market dominance of a few large firms have led to rising concentration and markups across various sectors. For instance, De Loecker et al. (2020) highlight the rise of highly concentrated industries in the US economy, while Koltay et al. (2021) document a similar trend in the EU, with the share of such industries doubling over the past two decades.[1] These trends underscore the risks associated with anti-competitive practices, as firms in concentrated industries gain increasing market power and reduce competitive dynamics.[2]

Cartels represent the most extreme form of market concentration, where firms actively suppress competition by coordinating behavior and maximizing profits. Understanding cartel birth and death dynamics is particularly crucial, as these collusive agreements may thrive in environments of economic uncertainty and volatility. The debate regarding the link between business cycles and cartel formation and stability dates back to the 1980s and remains an open question. Several theoretical (Rotemberg and Saloner, 1986; Haltiwanger and Harrington, 1991; Bagwell and Staiger, 1997; Fabra, 2006; Paha, 2017) and empirical studies (Ellison, 1994; Gallet, 1997; Suslow, 2005; Rosenbaum and Sukharomana, 2001; Levenstein and Suslow, 2011, 2016; Ghosal and Sokol, 2016; Hyytinen et al., 2018) have attempted to address this question, but the results are mixed and there is no consensus in the literature.

This paper examines how business cycles and other macroeconomic variables impact cartel formation and dissolution, providing insight into the link between economic fluctuations and collusive behavior. We find that GDP shocks - deviations from the trend - lead to an increase in the number of cartels in the economy. This effect occurs through a higher probability of cartel births and a lower probability of deaths. Similarly, rising interest rates, as a proxy for borrowing costs, are associated with more frequent cartel formations and fewer dissolutions. These findings emphasize the role of cartels as shock absorbers, enabling firms to cope with economic instability by providing a mechanism to increase (or stabilize) revenues and mitigate the effects of positive and negative shocks.

Most cartel studies are affected by the issue of sample selection bias, as they often focus exclusively on (illegal) convicted cases. Furthermore, the interaction between cartels and business cycles is inherently complex, both shaping and being shaped by market dynamics

[1] In the UK, the Competition and Markets Authority (2024) report reveals that markups increased by approximately 10 percent between 1997 and 2021, alongside greater market concentration, with fewer firms holding larger market shares.

[2] Although these have been highly influential papers, recent research has suggested that the increase in markups may also be due to how sectors are defined (Benkard et al., 2023) or due to technological changes that lower marginal cost (Conlon et al., 2023).

and economic stability. However, we argue that our approach is less susceptible to these limitations. First, we analyze a unique dataset on Swedish legal cartels (all of which fulfill the definition of a hardcore cartel) using a Hidden Markov Model. This combination of framework and data mitigates concerns about selection bias. Second, the long panel of cartel dynamics allows us to examine how industry collusion responds to past (lagged) macroeconomic developments across multiple business cycles, including repeated shocks. Furthermore, Sweden is a small open economy, highly exposed to global macroeconomic shocks (e.g., high inflation in the 1970s[3]), such that these can be considered exogenous. Lastly, the ideal setting would have a treatment and a control group. However, this is not feasible in our setting, as macroeconomic shocks and uncertainty impact all firms. To address this, we make use of the fact that the manufacturing sector is particularly vulnerable to such shocks. Manufacturing firms fundamentally differ from those in other industries: they often produce standardized goods, face more elastic demand, and are more sensitive to economic cycles and competitive pressures due to less localized markets. By comparing the results between manufacturing and non-manufacturing firms enables us to identify and analyze the differential impact of macroeconomic shocks across sectors.

As mentioned above, the theoretical prediction of how cartels respond to business cycles remains ambiguous. During economic downturns, firms may be more likely to engage in cartel-like behavior in order to stabilize revenues and reduce competition in shrinking markets. In a recession, for instance, declining demand and squeezed profit margins can drive firms to collude, maintaining artificially high prices and shielding participants from the full impact of reduced economic activity. However, during such periods, collusion may not be profitable enough to justify the possibility of detection and the cost of fines, complicating the overall incentive structure.

Our main finding is that cartel formation and stability are sensitive to economic shocks, with GDP deviations increasing cartel births and reducing cartel deaths in subsequent periods. This suggests that cartels are neither strictly pro-cyclical nor counter-cyclical, but instead thrive in volatile economic conditions. Shocks, whether positive or negative, alter firms' incentives by increasing uncertainty, making collusion more appealing as a strategy to stabilize prices or maximize profits. We also show how these incentives are sector sensitive, that is, cartel births and deaths are more or less sensitive to different macroeconomic variables depending on whether we examine manufacturing cartels or otherwise. In addition, industry-level and country-level data show consistent patterns in how shocks influence cartel dynamics. These results are of particular importance for prosecuted cartels - typically weaker ones - which tend to be more susceptible to the effects of business cycles.

[3]https://www.federalreservehistory.org/essays/great-inflation

This paper contributes to the literature on how business cycles influence the birth and death of cartels. Although theoretical arguments on this topic were proposed long ago, empirical evaluation has proven to be more challenging. Cartels may be more likely to form during periods of high industry growth as the potential gains from collusion increase. Green and Porter (1984) demonstrated that collusion can be sustained even under imperfect information about demand shocks. However, unexpected recessions reduce cartel stability because deviations by cartel members become indistinguishable from demand fluctuations. As a result, collusion may break down during recessions or demand downturns, not due to intentional cheating, but because firms struggle to differentiate between market shocks and rival defection. Rotemberg and Saloner (1986) showed theoretically that collusion can break down during periods of high demand. High demand increases temptation to cheat, and therefore collusion is harder in booms.

Empirical evidence on this issue is mixed. Some studies suggest that collusion is procyclical (e.g. Bagwell and Staiger (1997); Suslow (2005); Hyytinen et al. (2018)), while others argue it is counter-cyclical (e.g., Fabra (2006); Ghosal and Sokol (2016)). However, most of the empirical literature, with the exception of Levenstein and Suslow (2016)[4], focuses primarily on the number of cartels. We provide further insights into this question by using a Hidden Markov Model[5] and by separating between positive and negative shocks across different sectors.

Second, our paper is related to the literature on interest rates and collusion. Large interest rates have been shown to negatively correlate with the firm's discount factor, serving as a proxy for impatience. The literature offers mixed evidence on the impact of interest rates on cartels. Some authors suggest that higher interest rates decrease cartel stability (Dal Bó, 2007; Levenstein and Suslow, 2016) and hinder cartel formation (Levenstein and Suslow, 2016). In contrast, other research suggests that higher interest rates enhance cartel stability (Hellwig and Huschelrath, 2018) and cartel formation (Paha, 2017; Hellwig and Huschelrath, 2018). Meanwhile, Levenstein and Suslow (2011), analyzing 81 international cartels, find no relationship with cartel duration.

Finally, this paper also contributes to the empirical literature on cartel stability, using data on legal cartels. Indeed, much of the empirical literature uses data from prosecuted cartels, thus inevitably suffering from a sample selection bias. To avoid this bias, a limited number of papers using data on legal cartels study cartel's organizational form or stability under different legal framework (e.g., Hyytinen et al. (2019), Hyytinen et al. (2018), and

[4]Levenstein and Suslow (2016) examine 247 US cartels (1961-2013) and find no statistically significant relationship between cartel births, deaths and GDP shocks.

[5]This framework was also used in Hyytinen et al. (2018) to examine legal cartels in the Finnish manufacturing sector only.

Forsbacka et al. (2023)). In particular, Hyytinen et al. (2019) describe the Finnish cartel register (with 898 cartels) in detail. Hyytinen et al. (2018) study 364 Finnish manufacturing cartels and show that once cartels are born, they are persistent. Lastly, Forsbacka et al. (2023) examine how a gradual tightening of antitrust enforcement impacts (a population of 2318) Swedish legal cartels and show that strengthening antitrust enforcement has a deterrent effect, up to a threshold after which cartels continue to form but do so undercover.

However, this paper is the first to study the impact of business cycles on a full population of cartels for a given country. Our detailed dataset allows to distinguish between cartel births and deaths and their reaction to changes in macroeconomic variables.

The remainder of the paper is organized as follows. In the next section, we describe the data from the Swedish cartel register and the macroeconomic variables. Section 3 presents the empirical strategy. In section 4, we discuss the results on the effect of business cycles and other macroeconomic variables on cartel dynamics. Section 5 concludes.

2 Data

In this section, we describe the data on cartel dynamics and the macroeconomic environment, as well as additional data related to the legal framework and market characteristics.

2.1 Cartel dynamics

To study how cartels react to the macroeconomic landscape, we use a unique dataset on legal cartels in Sweden. The data comprise the population of cartel agreements registered in the Swedish cartel register (SCR) between 1946 and 1993. Firms were required to register any anti-competitive agreements they were part of upon request from the authorities, and failure to register could result in fines or imprisonment up to six months. The authorities identified competition-restricting agreements through special industry investigations, general requests sent out to firms and industry organizations, media coverage, or firms reporting anti-competitive agreements.

Of a total of 3,514 agreements in the SCR, 2,318 agreements are classified as cartels, following the OECD definition of hard-core cartels.[6] The other agreements in the SCR are primarily vertical agreements and agreements without any identifiable competition-hindering clauses.

[6] "(A)nti-competitive agreements, concerted practices or arrangements by actual or potential competitors to agree on prices, make rigged bids (collusive tenders), establish output restrictions or quotas, or share or divide markets by, for example, allocating customers, suppliers, territories, or lines of commerce" OECD/LEGAL/0452 2019.

The data cover the whole economy, except for the banking and insurance industries, which were regulated by a separate authority. The cartel agreements specify the products or services colluded on, which allows us to assign each cartel to an industry based on four-digit NACE codes. Most cartels operated in the manufacturing industry (63%), followed by wholesale and retail (14%).

The cartel agreements contain information about the dates on which the contracts began and ended, as well as when they were registered and deregistered from the SCR. This allows us to observe both the birth and the death of each cartel. In Section 3.3, we explain in detail how we model a cartel's birth and death.

The descriptive statistics for the data employed in the empirical analysis are shown in Table 1. For a detailed description of the data, see Le Coq and Marvão (2020).

In Table 3 in Appendix B, we present details on the share of collusive firms in each NACE sector for the years 1985 and 1990. Although there were many collusive firms in the economy, on average 6 to 7% of the active firms in a sector were collusive.

2.2 Macroeconomic environment

To study how cartels react to business cycles and growth in the economy's output, we use data on gross domestic product (GDP), measuring the value added created through the production of goods and services. The data comes from Edvinsson (2014), which is based on historical records compiled for the Swedish Central Bank (the Riksbank). We measure GDP in real terms, using a deflation index from Edvinsson and Söderberg (2014).

We detrend GDP using a *Hodrick-Prescott* (HP) filter, separating out the long-term trend (*GDP trend*) from cyclical components associated with the business cycles.[7] To capture the effect of the long-term trend, we include both the level and the quadratic term of *GDP trend* to allow for non-linearities in the relationships between output growth and cartel dynamics.

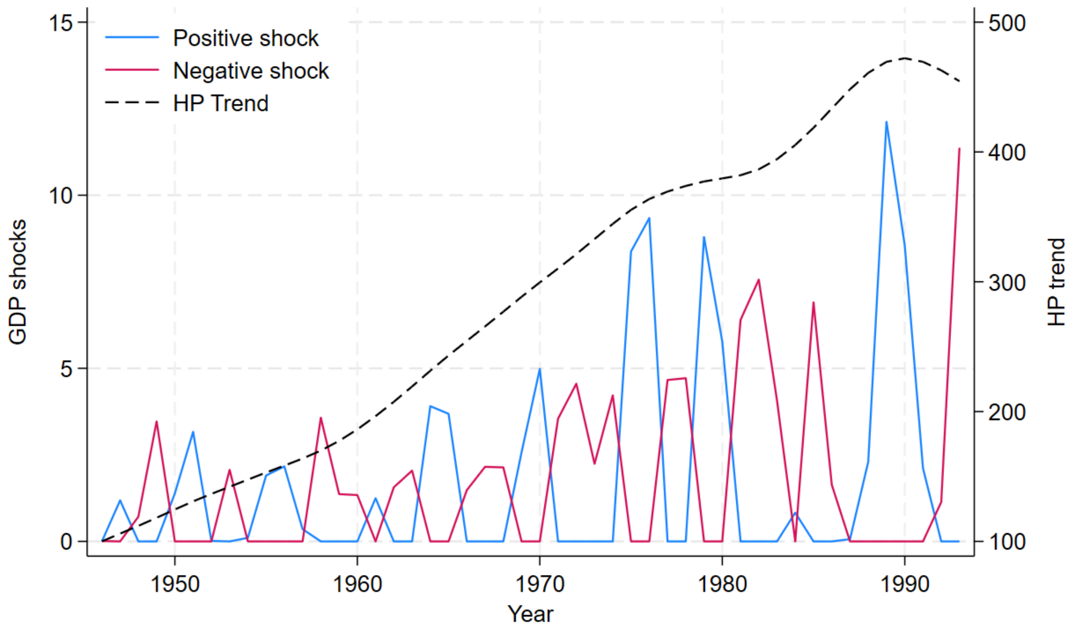
As positive and negative shocks can have potentially different impacts on cartels, we separate shocks into deviations above the trend (*GDP positive shocks*) and deviations below the trend (*GDP negative shocks*).

The evolution of the GDP trend and the positive and negative GDP shocks can be seen in Figure 1. In general, the GDP trend grew steadily, with much larger shocks in the latter half of the study period.

In robustness tests, we use data on gross value added (GVA) at the broad industry level (1-digit NACE codes) to study industry-level shocks. In contrast to GDP, which captures the overall dynamics in the economy, GVA captures the market dynamics. Data on GVA

[7]As is standard for annual data, we use a smoothing parameter of 6.25 (following Ravn and Uhlig, 2002).

Figure 1: GDP in Sweden, 1946-1993



Notes: Data on GDP comes from Edvinsson (2014).

come from historical national accounts by Edvinsson (2005). We detrend GVA in the same way as for GDP, resulting in *GVA trend* and short-term deviations from the trend, which are further divided into *GVA positive shocks* and *GVA negative shocks*.

In Appendix A, we show the development of the trend of GVA and the positive and negative shocks for one of the sectors, manufacturing, in Figure 3.

Table 1: Definitions and data sources

Variable	Definition	Mean	Std. Dev.	Min	Max
Cartel dynamics:					
Birth (PB)	Probability of cartel birth in year t and market i (4-digit NACE code)	0.03		0	1
Death (PD)	Probability of cartel death in year t and market i (4-digit NACE code)	0.16		0	1
Macroeconomic variables:					
GDP positive shock	GDP volume-GDP trend in year t (Edvinsson, 2014)	1.77	3.03	0	12.12
GDP negative shock	GDP volume-GDP trend in year t (Edvinsson, 2014)	1.77	2.51	0	11.371
GDP trend	GDP volume index (original series 100=1946) (Edvinsson, 2014)	287.43	120.86	100.01	472.19
GVA positive shock	GVA volume-GVA trend in year t (Edvinsson, 2005)	14.37	45.38	0	610.34
GVA negative shock	GVA volume-GVA trend in year t (Edvinsson, 2005)	14.37	45.53	0	514.66
GVA trend	GVA volume index (original series 100=1946) (Edvinsson, 2005)	1529.08	1884.21	91.82	9970.52
Real interest rate	Nominal interest rate-past-year inflation (Waldenström, 2014 & Statistics Sweden)	1.58	3.39	-13.62	7.49
Nominal interest rate	Measured as long-run government bond yields (Waldenström, 2014)	12.51	6.02	2.9	23.98
Additional variables:					
Homogeneity	Dummy (=1) if the product is homogeneous (4-digit NACE code)	0.18	0.38	0	1
Comp. restraints law (1953)	Dummy (=1) after the 1953 competition restraints law			0	1
Comp. restraints law (1956)	Dummy (=1) after the 1956 competition restraints law extension			0	1
Competition law (1982)	Dummy (=1) after the 1982 competition law			0	1

We also study the role of interest rates in cartel dynamics. Interest rates impact the firm's discount factor, affecting how they value future collusive profits relative to immediate gains from deviations. However, interest rates also affect the cost of capital and may limit the ability of firms to profitably deviate from a collusive agreement.

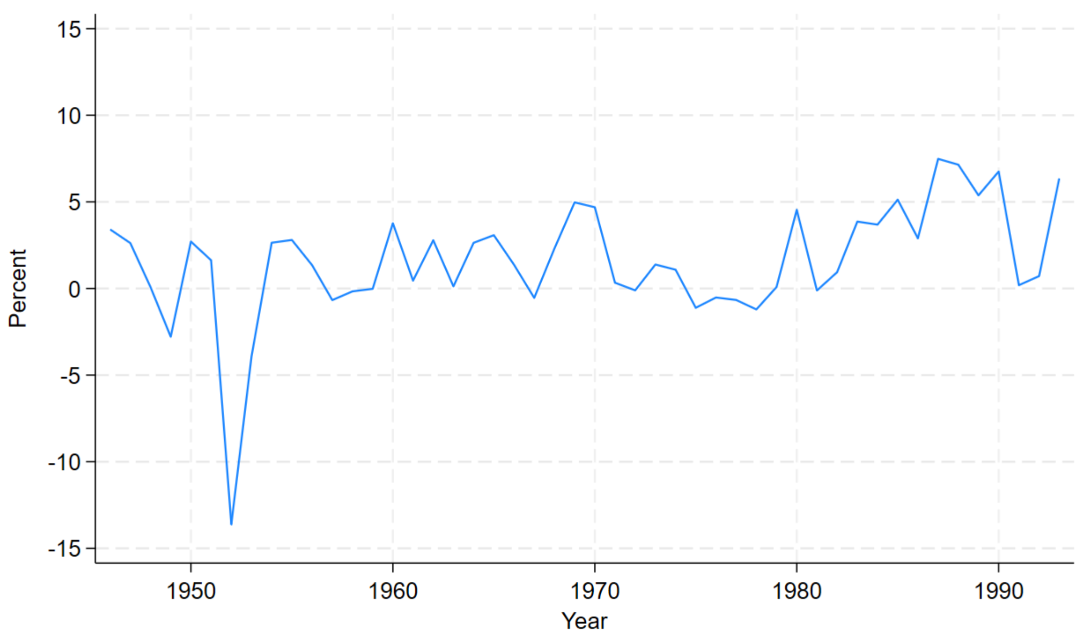
We focus on the real interest rate, which is the rate that firms face after accounting for inflation. The real interest rate is constructed by subtracting expected (previous-year) inflation from the nominal interest rate. The data on nominal interest rates come from Waldenström (2014) and we measure it as the long-run government bond yields. Inflation data comes from Statistics Sweden.

We include both the level and squared terms of the real interest rate, to allow for any potential nonlinearities in the relationship between the real interest rate and cartel dynamics.

Figure 2 depicts the development of the real interest rate. Real interest rates ranged widely between 0 and 5%, with a drop to minus 12% in 1952 and slightly higher levels with rates above 5% in the late 1980s.

In robustness tests, we also explore the relationship between nominal interest rate and cartel dynamics. We illustrate the trends for nominal interest rate and inflation in Figures 4 and 5 in Appendix A.

Figure 2: Real interest rate in Sweden, 1946-1993



Notes: The real interest rate is constructed based on data on nominal interest rates from Waldenström (2014) and inflation data from Statistics Sweden.

2.3 Additional variables

The homogeneity of products and services can influence the ease of collusion (Jacquemin et al., 1981; Hackner, 1994; Levenstein and Suslow, 2006; Hyytinen et al., 2018). For example, in more homogeneous markets, it may be easier to detect deviations from cartel agreements, thus making it easier to sustain cartels (DOJ 2010 Merger guidelines).[8] We therefore control for sector homogeneity using the Rauch index, which classifies products, by sector code, into homogeneous, differentiated and intermediary categories (Rauch, 1999).[9]

We also control for changes in the legal framework during the period under study. Cartels operated legally in Sweden until 1993, when they were prohibited as part of Sweden's accession to the European Union. Prior to this ban, competition law underwent three significant amendments. Each law increased the monitoring of cartels and limited the definition of a legal cartel.[10] Although cartels continued to operate legally during these transitions, Forsbacka et al. (2023) show that these amendments influenced both cartel births and deaths. To address this, we control for these three legal changes. Specifically, we incorporate three indicator variables, one for each amendment, set to 1 for all years after the respective law came into effect and 0 for all years prior.

3 Empirical strategy

The purpose of this paper is to establish a robust relationship between cartel dynamics and business cycles. To achieve this, a satisfactory empirical strategy must isolate the birth and death of cartels, use data on the full cartel population, and address the endogeneity issue arising from the relationship between the number of cartels and the economic context. We choose an empirical strategy specifically designed to address these challenges.

To model cartel dynamics, we apply a Hidden Markov Model (HMM). HMMs have been used in cartel studies to handle noise and incompleteness of the data (e.g., Ellison (1994), Hyytinen et al. (2018)). In our case, not all cartels might have been detected by the authorities, and some registered cartels might have died without notifying the authorities. To account for this, we use the HMM framework developed by Hyytinen et al. (2018), also used in Forsbacka et al. (2023).

We argue that endogeneity is unlikely to be a severe problem in our scenario for several reasons. First, Sweden is a small open economy, and macroeconomic trends are global (e.g.,

[8] DOJ-FTC (2010), paragraph 7.2.

[9] The Rauch classification covers only products; all service sectors are classified as differentiated (Gaisford and Kerr, 2008). To apply the Rauch classification, we convert the *Standard International Trade Classification system* (SITC, revision 2) classification used by Rauch into 4-digit NACE codes.

[10] For a detailed description of the legal development in Sweden, see Forsbacka et al. (2023).

high inflation in the 1970s[11]). Second, the macroeconomic variables we examine are lagged, thus at least partially addressing the reverse causality issue. Finally, in Table 3 we present details on the share of collusive firms in each NACE sector for the years 1985 and 1990. Although there were many collusive firms in the economy, on average, only 6 to 7% of the active firms in a sector were collusive. Consequently, cartel births and deaths are unlikely to have influenced GDP.

3.1 Cartel births and deaths

The HMM considers collusion at the market level. To apply the HMM, we map collusion to industry level, based on the 4-digit NACE codes assigned to each cartel. Based on the data from the SCR, we first classify industries as being *collusive* (C) or *non-collusive* (N). An industry is considered to be collusive in the year a cartel agreement started or was registered in the SCR, as well as in the year when there was some communication between the SCR and the cartel members. Similarly, an industry is considered to be non-collusive in the year a cartel agreement ended or was deregistered from the SCR. In all other years, we assume that the state of the industry is unknown.

A market is considered collusive (C) if there is at least one active cartel that year. A market is considered non-collusive (N) if all existing registered cartels in the market were inactive that year. In all other cases, the status of the market is considered to be unknown (U). We include all markets in the economy, including markets where there were no registered cartels during the whole time period, which allows us to consider potentially hidden cartels. This results in a panel of 578 industries across 47 years, with transitions between collusive and non-collusive states.

A *cartel birth* is defined as a year when there was collusion in an industry, conditional on there being no collusion in the year before (an N to C transition). We denote the probability of cartel birth by PB_{it}. Similarly, a *cartel death* is defined as a year when there was no collusion in the industry, conditional on there being collusion the year before (a C to N transition). The probability of cartel death is denoted by PD_{it}.

3.2 Hidden Markov Model

The HMM considers stochastic transitions between collusive and non-collusive states, according to a second-order Markov process. To examine our research question, we require a model of the second order to study cartel birth and death: to identify a cartel birth, we

[11] https://www.federalreservehistory.org/essays/great-inflation

must ascertain both that a cartel exists in a given time period and also that no cartel existed the year before, and vice versa for cartel deaths.

In the HMM framework, the *hidden state*, the true state of the industry, is distinguished from the *observed state*, which is observed from the data. The hidden state (H_{it}) represents whether the industry was truly collusive (C) or non-collusive (N) (giving in the state space $S_H = \{C, N\}$). We denote the probability of transitioning between collusive and non-collusive states (C and N states) as $a_{it}^{s_H} = Prob(H_{it} = s_{H,t} | H_{it-1} = s_{H,t-1}, \mathbf{x_{it}})$, where $\mathbf{x_{it}}$ is a vector of covariates.

The four possible transitions ($N - N$, $N - C$, $C - N$, and $C - C$) and the respective probabilities (which can be expressed in terms of PB_{it} and PD_{it}), can be summarized as follows

$$A_{it} = \begin{bmatrix} a_{it}^{NN} & a_{it}^{NC} \\ a_{it}^{CN} & a_{it}^{CC} \end{bmatrix} = \begin{bmatrix} (1 - PB_{it}) & PB_{it} \\ PD_{it} & (1 - PD_{it}) \end{bmatrix}. \tag{1}$$

The observed state corresponds to whether an industry is observed to be collusive or non-collusive. When the true state is observed, the observed state is identical to the hidden state. However, in some industries and some years, we do not observe the true state of the industry, which is then considered unknown (U) (thus giving the state space $S_O = \{C, N, U\}$).

We denote the probability of observing that an industry is collusive when it was collusive as $\beta_{it}^C = b_{it}^C(C)$, and the probability of observing that an industry is non-collusive when it truly was non-collusive as $\beta_{it}^N = b_{it}^N(N)$, where $b_{it}^{s_H}(s_O) = Prob(O_{it} = s_O | H_{it} = s_H, \mathbf{x_{it}})$, O_{it} being the observed data. The probability of not observing the true state (i.e. the true state is unknown) when the true state is collusive is denoted as $1 - \beta_{it}^C = b_{it}^C(U)$ and, similarly, the probability of not observing the true state when the true state in non-collusive is denoted $1 - \beta_{it}^N = b_{it}^N(U)$.

We assume that if the SCR observes collusion it will not be wrong, meaning that the register will not observe collusion when there was no collusion ($b_{it}^N(C) = 0$) nor observe that an industry was non-collusive when there was collusion ($b_{it}^C(N) = 0$).

This means that we can denote the observation probabilities as follows

$$B_{it} = \begin{vmatrix} b_{it}^N(N) & b_{it}^N(C) & b_{it}^N(U) \\ b_{it}^C(N) & b_{it}^C(C) & b_{it}^C(U) \end{vmatrix} = \begin{vmatrix} \beta_{it}^N & 0 & (1 - \beta_{it}^N) \\ 0 & \beta_{it}^C & (1 - \beta_{it}^C) \end{vmatrix}. \tag{2}$$

We then solve for these four unknowns, PB_{it}, PD_{it}, β_{it}^C, and β_{it}^N.

3.3 Estimation

We use a maximum likelihood estimation to estimate the probability of cartel birth (PB_{it}) and death (PD_{it}), along with the observation probabilities β_{it}^{C} and β_{it}^{N}. The following likelihood function indicates how likely it is that the model parameters describe the entire observed data.

$$L(\Theta; \mathbf{o}) = \prod_{i=1}^{N} \left((\mathbf{D_{i1}})' (\prod_{t=2}^{T_i} \mathbf{D_{it}}) \mathbf{1} \right). \tag{3}$$

In equation 3, Θ represents the model parameters and $\mathbf{o}$ denotes the realization of $\mathbf{O}$ (the data). $\mathbf{D_{i1}}$ is a (2 x 1) vector with the elements $d_{i1}^{k} = \tau_i^k b_{i1}^k(w)$, $\mathbf{D_{it}}$ is a (2 x 2) vector with the elements $d_{it}^{jk}(w) = a_{it}^{jk} b_{it}^{k}(w)$ for all $t > 1$, and $\mathbf{1}$ is a (2 x 1) vector of ones.

The probabilities of a cartel's birth and death (PB_{it} and PD_{it}) are modeled as functions of the macroeconomic variables - GDP shocks, GDP trend, and interest rate - controlling for homogeneity and legal variables. In robustness tests, we substitute GDP for GVA, and we also compare real and nominal interest rates.

The probabilities of observing cartels, β_{it}^{C} and β_{it}^{N}, are modeled based on previous registering activity and past cartel dynamics, to account for the number of cartels that had previously been enrolled and removed from the SCR, controlling for changes in the cartel legislation.

Following Hyytinen et al. (2018), standard errors are estimated using the inverse Hessian. In Table 4 in Appendix B we provide summary statistics for the variables described above, which are used to estimate the observation probabilities in the HMM.

Finally, we separately estimate this model for manufacturing and non-manufacturing sectors. This approach is particularly interesting because, although all firms are impacted by macroeconomic shocks and uncertainty, the manufacturing sector is generally more exposed to these shocks. Manufacturing firms differ fundamentally from those in other industries: they often produce standardized goods with more elastic demand, making them more susceptible to economic fluctuations and competitive pressures, particularly in less localized markets. However, due to the computational constraints of the Hidden Markov Model (HMM), it is not possible to analyze all sectors individually, since the HMM requires a sufficient volume of data to ensure convergence.

4 Results

This section presents the estimation results of how cartels respond to changes in the macroeconomic environment. The main results are reported in Table 2. The first two columns present pooled results for the entire sample, covering all sectors of the economy. We then proceed by separating the manufacturing sector from the remaining sectors.

In columns of odd numbers, the dependent variable is the *probability of cartel births* (PB), and in columns of even numbers, the dependent variable is the *probability of cartel deaths* (PD).

We begin by analyzing the effects of changes in GDP on cartels, followed by the impact of the interest rate. In all specifications, we control for the three main changes in cartel legislation during the study period and for product homogeneity.

The discussion of the estimates emphasizes the sign and statistical significance of the coefficients, as their magnitudes are less meaningful. More specifically, each coefficient reflects how a change in a given variable influences the likelihood of being in a particular state (that is, a state with cartel births or cartel deaths).

For completeness, in Table 5 in Appendix B, we report the entire HMM specification for the full economy, displaying all estimated coefficients and the estimations of the probabilities of observing collusion and non-collusion.

Table 2: Impact of the macroeconomic environment on cartel birth and death

	All sectors		Manufacturing		Non-manufacturing	
	(1)	(2)	(3)	(4)	(5)	(6)
	Birth (PB)	Death (PD)	Birth (PB)	Death (PD)	Birth (PB)	Death (PD)
GDP positive shock	0.059***	-0.122***	0.067***	-0.123***	0.009*	-0.000
	(0.012)	(0.017)	(0.018)	(0.021)	(0.005)	(0.002)
GDP negative shock	0.051**	-0.257***	0.089***	-0.216***	-0.001	-0.013**
	(0.021)	(0.027)	(0.029)	(0.033)	(0.009)	(0.006)
GDP trend	0.989***	1.362***	0.909***	0.652	-0.005	0.056**
	(0.249)	(0.352)	(0.317)	(0.427)	(0.028)	(0.028)
GDP trend^2	-0.214***	-0.171***	-0.214***	-0.059	-0.001*	-0.001**
	(0.045)	(0.061)	(0.057)	(0.074)	(0.000)	(0.000)
Real interest rate	-0.036***	-0.069***	-0.0205	-0.068***	0.496**	0.001
	(0.013)	(0.015)	(0.017)	(0.018)	(0.250)	(0.204)
Real interest rate^2	-0.004***	-0.005***	-0.001	-0.005***	-0.044**	-0.004
	(0.001)	(0.001)	(0.002)	(0.002)	(0.020)	(0.010)
Law controls	Yes	Yes	Yes	Yes	Yes	Yes
Homogeneity controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,743	27,743	11,039	11,039	16,703	16,703

Notes: Standard errors in parentheses. Statistical significance at the 1%, 5% and 10% level indicated as ***, **, and *, respectively. All macroeconomic variables are lagged one year.

4.1 Business cycles and collusion dynamics

Many studies on cartels use GDP trends or growth rates to capture changes in the macroeconomic environment. However, our extensive and detailed dataset enables us to tackle a more critical question at the center of current debates: whether GDP shocks drive cartel formation in a procyclical or countercyclical manner. Additionally, we examine how the relationship between collusion dynamics and GDP shocks varies between the manufacturing and non-manufacturing sectors.

GDP shocks

Our analysis reveals that both positive and negative shocks increase the probability of cartel formation (PB) and decrease the probability of cartel dissolution (PD).

As shown in columns (1) and (2) of Table 2, GDP shocks contribute to an overall increase in cartel activity. This indicates that GDP shocks create incentives for cartel formation and enhance the stability of existing ones, i.e., and thus that cartels may be a tool for providing stability during periods of higher volatility.

When we distinguish between the manufacturing and non-manufacturing sectors, it becomes evident that the observed effects are primarily driven by the manufacturing sector. The results for manufacturing (columns 3 and 4) closely mirror those for the entire sample (columns 1 and 2). In contrast, the findings for non-manufacturing sectors (columns 5 and 6) are less pronounced: positive shocks are linked to an increase in cartel births but have no impact on cartel deaths, while negative shocks have no effect on cartel births but are associated with fewer deaths. The divergence between manufacturing and other sectors is expected, as manufacturing firms differ fundamentally from those in other industries. They often produce standardized goods with more elastic demand, and are typically more sensitive to economic booms and competitive pressures due to less localized markets. Consequently, manufacturing cartels are naturally more sensitive to macroeconomic fluctuations.

As we discuss in more detail below, these findings are not driven by the inclusion of both GDP and interest rates in the specification, as shown in Table 6 in Appendix C. They also hold when GDP is replaced with GVA, as detailed in Table 8 in Appendix C.

GDP trends

Next, we examine the impact of the long-term trend in output. Theoretically, the impact of economic growth on cartel dynamics is ambiguous. On the one hand, firms may be more inclined to collude to capitalize on increased demand and higher profits. On the other hand, maintaining cartel stability during periods of growth can be challenging, as opportunities for greater profits outside the cartel may incentivize firms to deviate.

Our findings clearly illustrate this tension. Table 2 (columns 1-2) show that both the GDP trend and its squared term (GDP trend^2) have a statistically significant effect on cartel births and deaths, suggesting a non-linear, concave relationship. When we divide the sample into manufacturing and non-manufacturing cartels, the positive effect of the GDP trend is observed only for births in the manufacturing sector and only for deaths in the non-manufacturing sector.

In general, these findings suggest that both births and deaths of cartels increase with economic growth, but at a decreasing rate, and depending on the sector. Thus, while economic growth fosters the formation of new cartels, it also contributes to the dissolution of the existing ones.

This finding contributes to the ongoing debate on whether collusion is linked to business cycles. Some scholars argue that cartels are procyclical, forming during booms (e.g., Bagwell and Staiger (1997); Suslow (2005); Hyytinen et al. (2018)), while other suggest that they are countercyclical, emerging in recessions (e.g., Fabra (2006); Ghosal and Sokol (2016)), or acyclical, unaffected by the economic cycle (e.g., Levenstein and Suslow (2016)). Our results suggest a different perspective: cartels are neither inherently procyclical nor countercyclical, but instead act as shock absorbers, responding to periods of economic uncertainty and volatility. When the economy experiences positive shocks, such as periods of rapid growth, firms may form cartels to take advantage of rising demand. By colluding, they can keep prices higher than they would be in a competitive market, maximizing their profits. However, during negative shocks, such as recessions, cartels play a stabilizing role. Faced with declining demand and shrinking revenues, firms may use collusion to stabilize prices, reduce competitive pressures, and ensure their survival in challenging market conditions.

Ultimately, the results reinforce the idea that cartels act as shock absorbers, providing stability in uncertain times. Economic shocks, whether positive or negative, introduce uncertainty that firms seek to mitigate. By forming new cartels or maintaining existing ones, firms can reduce the risk associated with volatile market conditions, creating a buffer against sudden changes. This shows that cartels are not simply tied to economic growth or decline, but are a tool for managing the risks that come with unexpected changes in the economy.

4.2 Interest rates and collusion dynamics

Our second key finding relates to how cartels respond to changes in interest rates.

The results of the relationship between the real interest rate and the probability of cartel births and deaths are reported in Table 2. For the pooled sample (columns 1-2), the findings suggest that the real interest rate has a statistically significant impact on both cartel births and deaths. However, notable differences emerge when comparing the manufacturing and non-manufacturing sectors.

For manufacturing cartels (columns 3-4), we find that the real interest rate has a statistically significant effect on deaths but not on births. Specifically, higher interest rates are associated with a lower probability of cartel deaths, though the effect diminishes as interest rates increase further, as evidenced by the significant and negative squared term of the real interest rate is significant and negative. This suggests that manufacturing cartels become more stable during periods of high interest rates.

For non-manufacturing cartels (columns 5-6), the real interest rate exhibits a positive but diminishing effect on births, but no significant effect on deaths. Higher interest rates are associated with an increased probability of cartel births, though this effect weakens as interest rates rise further. This suggests that in non-manufacturing sectors, higher interest rates encourage cartel formation at a decreasing rate.

Overall, our results suggest that cartelization increases with higher interest rates, as cartels in manufacturing become more stable and more cartels form in non-manufacturing sectors.

To better comprehend the mechanism at play, we discuss how interest rates can affect cartels. Interest rates influence firms' discount factor, affecting how they value future collusive profits relative to immediate gains from deviations. A higher interest rate lowers the discount factor, reducing the value of future profits and diminishing the incentives to collude. In addition, interest rates affect the cost of capital, with higher rates increasing production costs. This can limit firms' ability to profitably deviate from a collusive agreement, as undercutting the cartel price to capture a larger market share may not be financially viable when production costs are high. Additionally, breaking the cartel could endanger the firm's survival in a high-interest-rate environment, despite the potential for short-term gains.

Our results, which show that higher interest rates are associated with increased cartelization, indicate that interest rates, as a proxy for the cost of capital, play a more significant role in our setting. Forming and sustaining cartels may help firms survive in times of economic hardship, preserving stability during challenging times.

For the non-manufacturing sector, our results suggest that the real interest rate is an important driver of new cartels. This finding is particularly noteworthy because we do not find a comparable effect in the manufacturing sector, which is generally more sensitive to macroeconomic changes. One possible explanation is that firms in non-manufacturing sectors are often smaller and operate with lower profit margins, making them especially vulnerable to short-term increases in production costs. The formation of cartels can serve as a survival strategy, helping these firms avoid bankruptcy.

Our results contribute to the limited and often conflicting empirical literature on the impact of interest rates on cartels. Specifically, our finding that higher interest rates appear to increase cartel stability aligns with studies such as Hellwig and Huschelrath (2018), Dal Bó (2007) and Lenhard (2024). Similarly, the positive relationship we find between real interest rates and the probability of cartel births is consistent with the findings of Hellwig and Huschelrath (2018) and Paha (2017). Our results are also related to the finding in Dal Bó (2007) that the variability in interest rates decreases cartel stability (the opposite result the author observes for the level of interest rates), as some of this variability is picked up by the business cycles in our setup.

To further explore the role of interest rates, we analyze the effect of using nominal interest rates instead of real interest rates, as detailed in Table 7 in Appendix C. The results indicate that nominal interest rates do not have a statistically significant effect on cartel births or deaths. This highlights the importance of the *real* interest rate, which accounts for inflation and offers a more accurate measure of the true cost of borrowing. In contrast, nominal interest rates, by not accounting for inflation, fail to capture the full set of factors influencing firms' decisions.

4.3 Discussion and Robustness

We now assess the robustness of our main results by controlling for sector-level business cycles and by splitting the sample into different time periods.

Gross Value Added by sectors

Our main findings are derived from using GDP data to examine the impact of economic shocks on the formation and dissolution of cartels. As a broad indicator of a country's economic performance, GDP is valuable for understanding how economic conditions influence cartel dynamics.

However, the literature highlights the importance of market characteristics in cartel formation (a survey of the early literature can be found in Levenstein and Suslow (2006)) and suggests that price wars can emerge from changes in market-specific characteristics (Slade, 1989, 1990). In this sense, GDP data is less precise for analyzing individual markets, as it includes broader elements such as taxes and subsidies that may not directly pertain to cartel activities. Therefore, in this part, we focus on the role of gross value added (GVA). GVA captures the value added by specific markets, offering a more granular and market-specific perspective compared to GDP, while remaining correlated with it. This specificity makes GVA potentially more suitable for analyzing firm behavior (and, by extension, cartel behavior) within specific markets, which is complementary to our research question.

The results of this analysis are presented in Table 8 in Appendix C, which reveals two notable differences compared to the baseline estimations. First, the effect of the GVA trend on the probability of cartel births is no longer statistically significant. Second, real interest rates are no longer statistically significant in explaining the variation in cartel deaths. As we show in the previous section, the impact of interest rates varies between sectors. Consequently, the effect of interest rates is partially accounted for by changes in GVA.

Overall, these findings suggest that while both market-level and country-level shocks affect the likelihood of cartel births and deaths in similar ways, the long-term trend in country-level output (GDP) plays a far more significant role in explaining cartel deaths than the trend in sector-level output (GVA). This difference arises because the GDP trend captures broader economic conditions that give incentives to coordination to manage market growth and competition, whereas the GVA trends primarily reflect localized, market-specific dynamics.

Differences over time

In this part, we perform a robustness check to examine whether the patterns described above hold consistently over time. A notable feature of the data is the sharp decline in cartel registrations during the 1980s, with no new cartel agreements recorded in the SCR after 1979, although other competition-restricting agreements continued to be registered.

To assess how the results may vary over time, we conduct a robustness check by splitting the sample into two periods: the first half (1946-1969) and the second half (1970-1993). This allows for a comparison of the findings across time frames. The results of this analysis are reported in Table 9 in Appendix C.

The differences between the two periods highlight how economic and legal changes shaped the dynamics of cartel behavior. During the earlier period, GDP shocks encouraged cartel formation, while in the later period, these shocks contributed to the stabilization of existing cartels. This led to a phase of intense cartel formation in earlier years, followed by a wave of cartel deaths, especially as the 1993 ban on cartels approached.

5 Conclusion

The purpose of this paper is to examine the impact of business cycles (short-term economic fluctuations) on the formation and dissolution of cartels. One potential concern is endogeneity, in which an increase in cartel numbers could have an adverse impact on GDP levels. However, we argue that by applying a Hidden Markov Model to a population of legal cartels in Sweden from 1947 to 1993, our empirical strategy effectively addresses these concerns. In light of Sweden's relatively small economy and the fact that cartels accounted for an average of 6-7% of firms within a sector, GDP shocks can be considered largely exogenous, further mitigating endogeneity concerns.

Our main finding is that GDP shocks and higher interest rates increase the number of cartels by increasing the probability of cartel formation and reducing the likelihood of cartel death. These results suggest that cartels are not simply tied to macroeconomic trends but rather may serve as a mechanism for firms to navigate periods of heightened economic uncertainty.

The results also underscore the importance of considering sector-specific characteristics when studying cartel behavior. In particular, we show that the impact of GDP shocks and interest rates on cartel dynamics is more pronounced in the manufacturing sector compared to non-manufacturing sectors.

These results are of particular importance for prosecuted cartels, typically weaker ones, which tend to be more susceptible to the effects of business cycles.

These findings may also suggest that policymakers may wish to strengthen antitrust enforcement during times of economic stress, as economic fluctuations appear to stabilize cartels.

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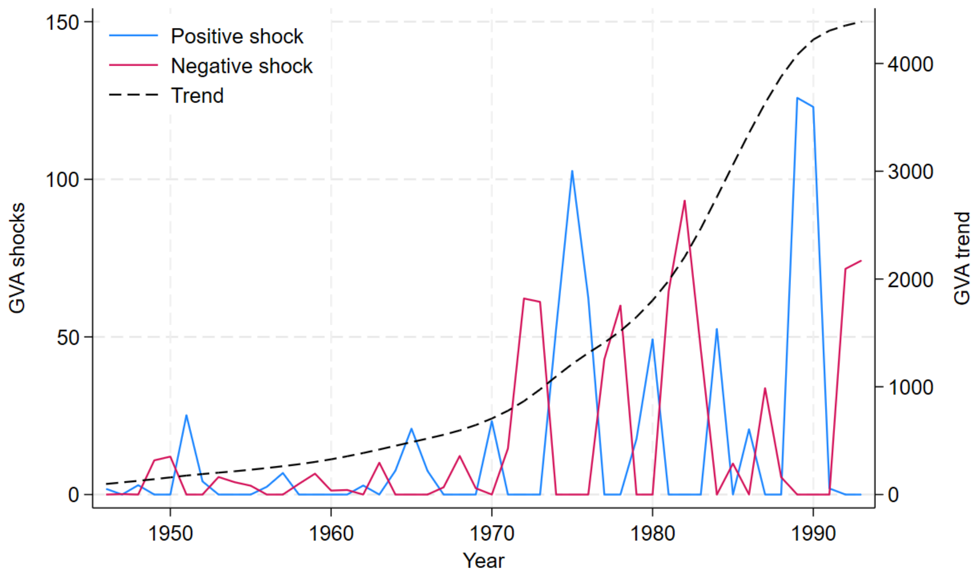
Appendix

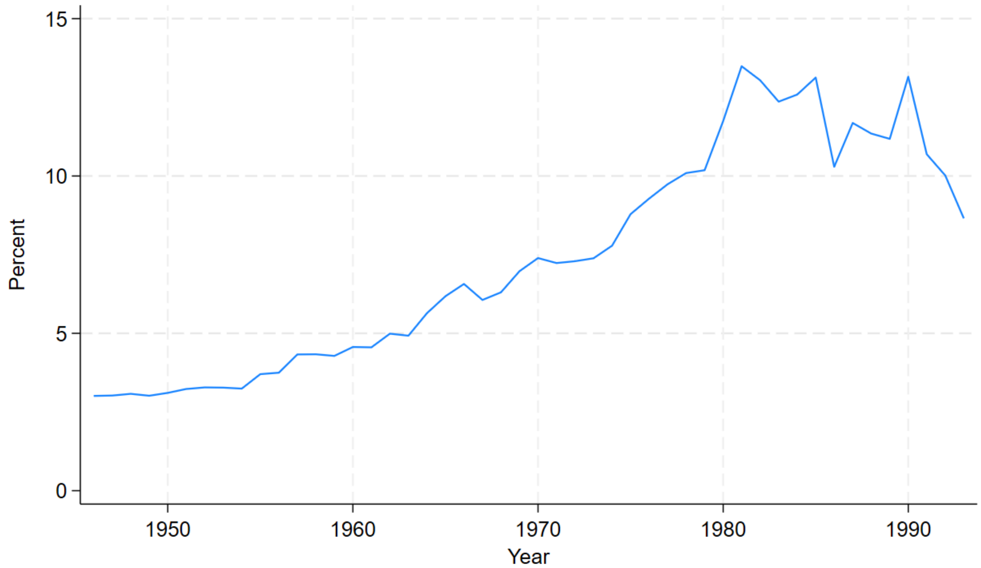
A Additional Figures

Figure 3: GVA for the manufacturing sector in Sweden, 1946-1993



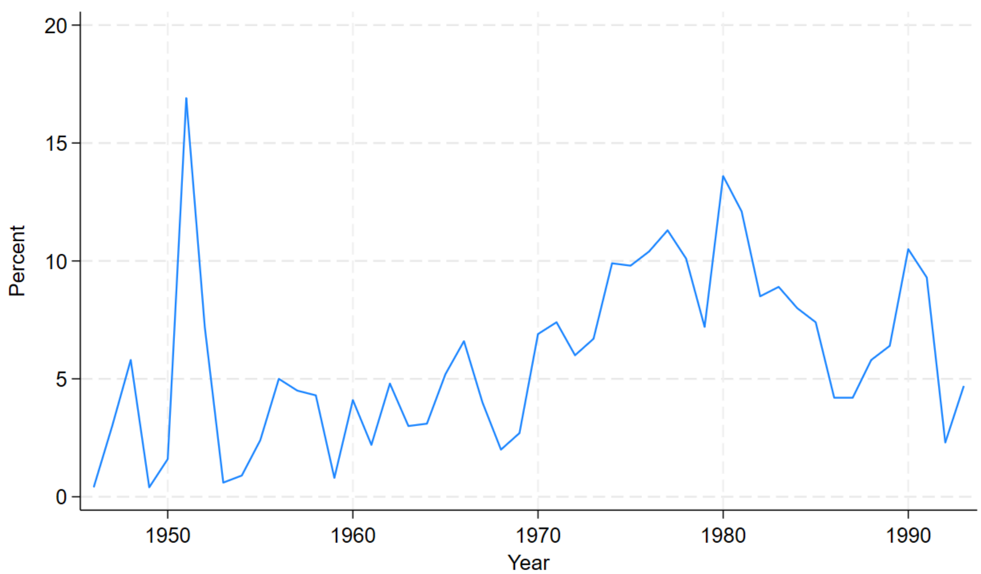
Notes: Data on GVA comes from Edvinsson (2005).

Figure 4: Nominal interest rate in Sweden, 1946-1993



Notes: The nominal interest rate is measured as the long-run government bond yields and the date comes from Waldenström (2014).

Figure 5: Inflation in Sweden, 1946-1993



Notes: Data on inflation comes from Statistics Sweden.

B Additional Tables

Table 3: Share of active cartel members (firm-level) in each NACE sector, in Sweden, in 1985 and 1990.

	1985		1990	
NACE	Cartel firms	Share of sector	Cartel firms	Share of sector
A	12,593	5.60%	11,050	4.92%
B	565	0.25%	601	0.27%
C (Manufacturing)	25,457	11.33%	28,644	12.75%
D,E	1,544	0.69%	1,479	0.66%
F	17,820	7.93%	23,663	10.53%
G (Wholesale and retail trade)	52,574	23.40%	57,107	25.42%
H	16,125	7.18%	18,762	8.35%
I	6,573	2.93%	7,854	3.50%
J,K	5,139	2.29%	5,825	2.59%
L	5,692	2.53%	7,382	3.29%
M,N	13,752	6.12%	24,443	10.88%
O	4,313	1.92%	4,230	1.88%
P	44,569	19.84%	49,158	21.88%
Q	0	0.00%	0	0.00%
R,S	15,832	7.05%	18,495	8.23%
T	2,141	0.95%	2,851	1.27%
U	9	0.00%	13	0.01%
Total	224,698		261,557	
Min.		0.00%		0.00%
Max.		23.40%		23.42%
Average		5.88%		6.85%

Note: The data on the total number of active firms in each year, for each NACE code, was provided by Statistics Sweden.

Table 4: Definitions and summary statistics for variables used to estimate observation probabilities in the HMM.

Variable	Definition	Mean	Std. Dev.	Min	Max
Observation probabilities:					
β^C	Probability of observing collusion	0.726			
β^N	Probability of observing non-collusion	0.052			
Cartel/registration activity:					
Deaths (stock)	Number of cartels exited from the SCR by $t-1$	14.31	8.23	0	2,800
Deaths (flow)	Number of cartels exited from the SCR in $t-1$	58.33	55.07	0	345
Births (stock)	Number of cartels entered in the SCR by $t-1$	14.47	8.38	0	2,836
Births (flow)	Number of cartels entered in the SCR in $t-1$	59.08	56.78	0	206
Market (count)	Number of cartels registered in market i by $t-1$	3.20	10.24	0	148

Table 5: Impact of the macroeconomic environment on cartel birth and death, probability of observing collusion, and initial probability of collusion.

	(1) Birth (PB)	(2) Death (PD)	(3) β^N	(4) β^C	(5) α
GDP positive shock	0.0742***	-0.1080***			
	(0.0148)	(0.0170)			
GDP negative shock	0.0973***	-0.1892***			
	(0.0189)	(0.0221)			
GDP trend	0.8482***	1.0039***			
	(0.2374)	(0.3273)			
GDP trend^2	-0.1950***	-0.1166**			
	(0.0436)	(0.0001)			
Homogeneity	-0.1035*	-0.1645**			0.3202**
	(0.0700)	(0.0697)			(0.1448)
Comp. restraints law (1953)	0.0996	0.4675***	0.1675	-0.2580	
	(0.1134)	(0.1441)	(0.1371)	(0.2119)	
Comp. restraints law (1956)	0.0300	-0.6109***	0.6583***	-0.7881***	
	(0.1089)	(0.1462)	(0.1078)	(0.2011)	
Competition law (1982)	0.2987**	0.4284***	0.5643***	0.2332**	
	(0.1222)	(0.1454)	(0.0300)	(0.1096)	
Market (count)			-0.0060**	0.02214***	
			(0.0028)	(0.0029)	
Death (stock)			0.0002		
			(0.0070)		
Death (stock^2)			0.0000		
			(0.0002)		
Death (flow)			0.0001		
			(0.0002)		
Birth (stock)				0.0031	
				(0.0111)	
Birth (stock^2)				0.0000	
				(0.0004)	
Birth (flow)				0.0017***	
				(0.0006)	
Constant	-3.0398***	-2.3781***	-2.5701***	1.1909***	-0.7968***
	(0.2277)	(0.3084)	(0.0958)	(0.1127)	(0.0655)
Observations	27,743	27,743	27,743	27,743	27,743

Notes: Standard errors in parentheses. PB is the probability of cartel birth, PD the probability of cartel death, β^C the probability of observing collusion, β^N the probability of observing non-collusion, and α the probability that the initial state is collusive. Standard errors in parentheses. Statistical significance at the 1%, 5% and 10% level indicated as ***, **, and *, respectively. All macroeconomic variables are lagged one year.

C Robustness Tests

Table 6: Impact of the macroeconomic environment on cartel birth and death - Robustness test: excluding interest rate

	All sectors		Manufacturing		Non-manufacturing	
	(1)	(2)	(3)	(4)	(5)	(5)
	Birth (PB)	Death (PD)	Birth (PB)	Death (PD)	Birth (PB)	Death (PD)
GDP positive shock	0.074***	-0.108***	0.085***	-0.111***	0.013**	0.000
	(0.015)	(0.017)	(0.022)	(0.022)	(0.005)	(0.002)
GDP negative shock	0.097***	-0.189***	0.123***	-0.146***	0.012*	-0.010**
	(0.019)	(0.022)	(0.028)	(0.027)	(0.006)	(0.004)
GDP trend	0.848***	1.004***	0.871***	0.283	-0.014	0.042***
	(0.237)	(0.327)	(0.317)	(0.404)	(0.015)	(0.015)
GDP trend^2	-0.195**	-0.117**	-0.215***	-0.001	-0.001**	-0.001***
	(0.044)	(0.000)	(0.059)	(0.070)	(0.000)	(0.000)
Law controls	Yes	Yes	Yes	Yes	Yes	Yes
Homogeneity controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,743	27,743	11,039	11,039	16,703	16,703

Notes: Standard errors in parentheses. Statistical significance at the 1%, 5% and 10% level indicated as ***, **, and *, respectively. All macroeconomic variables are lagged one year.

Table 7: Impact of the macroeconomic environment on cartel birth and death - Robustness test - Nominal interest rate instead of real interest rate

	Baseline			
	(1)	(2)	(3)	(4)
	Birth (PB)	Death (PD)	Birth (PB)	Death (PD)
GDP positive shock	0.074***	-0.108***	0.016***	0.000
	(0.015)	(0.017)	(0.004)	(0.001)
GDP negative shock	0.097***	-0.189***	0.011***	0.002
	(0.019)	(0.022)	(0.004)	(0.002)
GDP trend	0.848***	1.004***	0.022	-0.003
	(0.237)	(0.327)	(0.014)	(0.013)
GDP trend^2	-0.195**	-0.117**	-0.002***	0.000
	(0.044)	(0.000)	(0.000)	(0.000)
Nominal interest rate			-0.001	0.0475
			(0.031)	(0.034)
Nominal interest rate^2			-0.001	-0.001
			(0.001)	(0.001)
Law controls	Yes	Yes	Yes	Yes
Homogeneity controls	Yes	Yes	Yes	Yes
Observations	27,743	27,743	27,743	27,743

Notes: Standard errors in parentheses. Statistical significance at the 1%, 5% and 10% level indicated as ***, **, and *, respectively. All macroeconomic variables are lagged one year.

Table 8: Impact of the macroeconomic environment on cartel birth and death, using gross value added (GVA) - Robustness test: GVA instead of GDP

	(1) Birth (PB)	(2) Death (PD)	(3) Birth (PB)	(4) Death (PD)
GVA positive shock	0.002**	-0.002*	0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
GVA negative shock	0.002**	-0.006***	0.002*	-0.006***
	(0.001)	(0.002)	(0.001)	(0.002)
GVA trend	81.075	164.099*	32.281	192.373**
	(79.869)	(96.631)	(71.562)	(96.850)
GVA trend^2	-54908.34***	-907.299	-39643.28***	-3353.382
	(19156.22)	(15603.07)	(13670.62)	(15539.56)
Real interest rate			-0.036***	-0.004
			(0.010)	(0.012)
Real interest rate^2			-0.005***	0.000
			(0.001)	(0.001)
Law controls	Yes	Yes	Yes	Yes
Homogeneity controls	Yes	Yes	Yes	Yes
Observations	27,743	27,743	27,743	27,743

Notes: Standard errors in parentheses. Statistical significance at the 1%, 5% and 10% level indicated as ***, **, and *, respectively. All macroeconomic variables are lagged one year.

Table 9: Impact of the macroeconomic environment on cartel birth and death - Robustness test: Time split

	1946-1969		1970-1993	
	Birth (PB)	Death (PD)	Birth (PB)	Death (PD)
GDP positive shock	0.096***	0.003	0.009	-0.061***
	(0.029)	(0.043)	(0.025)	(0.021)
GDP negative shock	0.093***	0.028	-0.008	-0.187***
	(0.033)	(0.046)	(0.039)	(0.027)
GDP trend	1.434	4.031***	3.882	6.024***
	(0.894)	(1.242)	(2.544)	(1.920)
GDP trend^2	-0.297	-0.953***	-0.613*	-0.976***
	(0.209)	(0.292)	(0.356)	(0.255)
Constant	-3.584***	-4.984***	-8.260*	-10.448***
	(0.753)	(1.042)	(4.476)	(3.556)
Law controls	Yes	Yes	Yes	Yes
Homogeneity controls	Yes	Yes	Yes	Yes
Observations	27,743	27,743	27,743	27,743

Notes: Standard errors in parentheses. Statistical significance at the 1%, 5% and 10% level indicated as ***, **, and *, respectively. All macroeconomic variables are lagged one year.