INTEREST RATE MARGINS: A DECOMPOSITION OF DYNAMIC OLIGOPOLISTIC CONDUCT AND MARKET FUNDAMENTALS*

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December 13, 2004

Abstract

We propose a model in which the evolution of interest rate margin (mark-up) in banking is the outcome of two major components: (i) dynamic oligopolistic conduct, and (ii) dynamics of market fundamentals. The model is specified such that oligopolistic dynamics are separated from the dynamics of fundamentals. Results indicate that margins are significantly different from the traditional measure once fundamentals are filtered out.

Keywords: Oligopoly, Conduct, Dynamics, Fundamentals, Banking,

JEL classification: L13, L16, G21

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*We thank Aharon Meir Center for Banking at Bar-Ilan University for financial support. We are grateful to Pedro Pita Barros, Michael Beenstock, Ben Eden, David Genesove, Margaret Slade, Yossi Spiegel, and seminar participants at the Bank of Israel, The Hebrew University, the 27th E.A.R.I.E conference in Lausanne. The participants in the Second Tel-Aviv Workshop on Industrial Organization and Anti-Trust, especially Sofronis Clerides, Chaim Fershtman, David Gilo, Ariel Pakes and Bob Willig raised very important and constructive issues.

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1. Introduction

The banking industry has witnessed significant changes during the past several decades concerning markup fluctuations, institutional evolution, and technological changes. The prime interest of this paper is to offer a methodology for the decomposition of markup (net interest margins) evolution into its fundamental-driven and conduct-induced components. The relative importance of these different components in generating markup-dynamics can provide new perspective for the understanding of these dynamics, and in addition can shed light on policy alternatives concerning this important sector.

The issue we are concerned with in this paper is the extent to which the measured markup reflects the dynamics of conduct, rather than that of market fundamentals. Specifically, we present a model which decomposes changes in economic rents (net interest margins) into changes emanating from the dynamics of various firm, industry, and macroeconomic characteristics, henceforth termed “fundamentals”, and those emanating from oligopolistic dynamics.\(^1\)

Imperfect competition and firm/industry conduct has been the focus of numerous studies. Evidence on the existence of market power (mark-up) in the US economy, for instance, has been documented recently in Hall (1988) and Roeger (1995). A very important observation made recently by Demirguc-Kunt, Laeven, and Levine (2003) documents the fact that the conventional positive relationship between concentration and net interest margins breaks down when controlling for exogenous factors such as regulatory restrictions and various macroeconomic factors. This observation points to the complex interplay between conduct and fundamentals and deserves further efforts to be exerted into the clearer understanding of this relationship.\(^2\)

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\(^1\)In the sequel we define fundamentals more precisely.

\(^2\)Domowitz (1993) p. 215, articulates this phenomenon as follows: “Attributing observed departures of price from marginal cost to generic descriptions of imperfect competition or market power can be seriously misleading”. Borenstein, Bushnell, and Wolak (1999) show, in the context of electricity markets, that if opportunity cost exceeds that of production cost, positive markup by itself is not a proof of market power abuse.
Various supply, demand, and institutional factors which might bring about market failure may mask the true conduct of firms and industries and thus contribute to inaccurate conclusions regarding conduct. Stiglitz (1984) e.g., elaborates on the existence of positive markups in perfectly competitive environments stemming from factors such as imperfect information to changes in demand elasticity over the business cycle. Natural monopoly provides another example: conditions of non-constant returns to scale might affect the estimated markup, biasing thereby the estimated conduct. Another example can be found in the financial sector where characteristics such as asymmetric information, risk considerations, adverse selection, and moral hazard may induce an apparent imperfectly competitive conduct. At the industry level, the state of the economy has an important role in shaping the economic environment and, consequently, cyclical phenomena exert influence on the sectorial dynamic behavior of market power. In fact, various recent analyses pertaining to the profitability of banks document very low explanatory power when ignoring changes in fundamentals; see for instance, Berger (1995) who documents $R^2$ values which are almost all less than 0.2. Berger and Mester (2001) show that controlling for some fundamentals increases the explanatory power to $R^2 = 0.4$. Some other recent studies, (Humphrey and Pulley (1997); Valverde, Humphrey, and Fernandez (2001)) report important influence of fundamentals (not banks’ decision rules) on cost and profitability. Berger and Mester (2001) document significant influence of changes in the fundamentals they specify. Thus, the emerging picture is indicative of the

3As Klette and Griliches (1996) argue, “one problem with the empirical research...is that the estimated markup is critically dependent on the assumption of constant returns to scale. If the firms in fact are operating with short run decreasing returns to scale, their markup estimates might be an artifact due to the erroneous assumption of constant returns” (p.3). Berg and Kim (1994) show that the measurement of firm’s technology and efficiency is crucially dependent on the (non) treatment of conduct.

4In a recent analysis of the relationship between market power and bank risk, Covitz and Heitfield (1999) find that the seriousness and degree of a bank’s moral hazard determines the direction of the price-cost margins.

5Humphrey and Pulley (1997), Berger and Mester (2001) and Valverde, Humphrey, and Fernandez (2001) use terms like “external business environment” or “economic (business) conditions” to represent externally initiated adjustments, which we term fundamentals.
importance fundamentals exert on banks behavior and resulting performance.

The prime purpose of this paper is thus to offer a methodology for the decomposition of markup evolution into its fundamentals-driven and conduct-induced components. This may be an important task from a policy perspective, as policy instruments are much more prone to regulate oligopolistic dynamics than the dynamics of fundamentals.

It is well known that perfect competition in some sectors, inter-alia the financial sector, may result in a non-optimal number of firms. In an interesting observation Gale (1992) notes that when switching costs and non observable quality of banking services are considered, it may not be clear that competition in its most desirable form can be identified with a large number of small banks. A recent paper by Gan (2004) empirically documents previously reached theoretical results of Allen and Gale (2000), Hellman, Murdock, and Stiglitz (2000) and Besanko and Thakor (1993), showing that competition in the banking sector can reduce franchise value which in turn induces risk taking and moral hazard problems, ultimately leading to financial instability. In fact, perfectly competitive conduct, as measured by conventional price-cost margins, in such sectors may not even be a normative benchmark as far as public policy is concerned. Other characteristics are inherently intrinsic to the conduct of many industries independently of their (alleged) oligopolistic conduct. Thus, one would eventually want to separate out outcomes which are the result of the above mentioned structural characteristics (fundamentals) from results which are due to oligopolistic conduct.

In our model, prices (or economic rents) are affected directly by changes in market fundamentals, and indirectly by changes in oligopolistic dynamics (market arrangements), which themselves emanate from changes in these fundamentals.

The paper is organized as follows. A brief discussion of related issues is presented in Section 2. The decomposition methodology is presented in Section 3. The model is applied to the financial intermediation sector in Section 4, and the empirical
methodology and results are discussed in Section 5. Section 6 concludes the paper.

2. Discussion

Many studies have examined the nature of markup fluctuations over the business cycle (Haltiwagner and Harrington (1991), Chevalier and Scharfstein (1996), Rotemberg and Saloner (1986), Rotemberg and Woodford (1992), Domowitz, Hubbard, and Petersen (1986), Carlton (1997), to mention a few). For changes in markups to occur one needs to appeal to some form of market failure or to some form of oligopolistic conduct. Evidently, changes in the behavior of markups are often negatively correlated with the business cycle. Chevalier and Scharfstein (1996), for instance, draw upon the effects of capital-market imperfections on product-market competition to show that markups are countercyclical because firms may be less able to collude during booms. Firms may change their behavior during the business cycle by colluding, rationing their outputs, and the like. We are concerned with the separation of the cyclical component of markups and oligopolistic behavior.

Generally in the literature, a game-theoretic model specifying the exact nature of imperfect competition is used to arrive at predictions for the dynamic behavior of prices and markups. It is well known though, that the resulting behavior of prices and markups is model-specific. One example is the Green and Porter (1984) model which was empirically estimated by Porter (1983) using a switching regression technique applied to time series data on the Joint Executive Committee (JEC) railroad cartel form 1880 to 1886, and then reexamined by Ellison (1994). There is an advantage to using particular models when detailed information regarding the actual market conduct to which the model’s performance and predictions can be compared and assessed. However, in the absence of such information, an empirical specification which does not rely on modelling specific and stylized games, may be preferred.

Also, the empirical application of some of the aforementioned models may require
the problematic specification of proxies for market power. In a recent article, Corts (1999) provides interesting criticism regarding the use of the conduct parameters method in dynamic oligopoly models. Furthermore, when interest is focused on the role played by imperfect competition on prices and markups, as is the case in the recent literature (Carlton (1997), Hall (1988), Silvestre (1993)), one has to realize that price and markup fluctuations may result from two broadly-categorized interrelated sources. One is the changes in the economy’s fundamentals as shown in Bils (1989) for the case of a change in demand elasticities, or Ghosal (2000) for changes in both supply and demand, and the other is changes in the dynamics of oligopolistic conduct as demonstrated in Rotemberg and Saloner (1986), Rotemberg and Woodford (1992), and Haltiwagner and Harrington (1991), for the case of tacit collusion. Chevalier, Kashyap, and Rossi (2000) find that the pattern of margin changes they observe can better be empirically explained by retailer advertising competition which, of course, is a function of fundamentals such as the state of demand. Given that markup dynamics are the result of these two interrelated sources, it is apparent that one would want to filter out the dynamics of fundamentals from the measured (total) markup-dynamics in order to separate out and identify the behavior of (oligopolistic) conduct-dynamics. This is exactly the aim and scope of the present paper.

The approach taken in this paper differs from the approaches taken in the aforementioned literature in that the dynamics of markup is specified in the spirit of Flood and Garber (1983) as a stochastic process characterized by discrete changes.

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6Chirinko and Fazzari (1994) use the Lerner index and Ghosal (2000) employs concentration ratios both of which may or may not accurately depict market power.

7We should emphasize that Chevalier, Kashyap, and Rossi (2000) are able to test their proposed model by nesting it along with cyclical firm-conduct (tacit collusion) models a la Rotemberg and Saloner (1986) and Rotemberg and Woodford (1992) and those a la Bils (1989) which draw on demand elasticities.

8It is believed that changes in banks decision rules are not continuous but rather discrete. Humphrey and Pulley (1997) for instance, average their data for individual banks over three successive four-year intervals believing “it unrealistic to assume that profit maximizing behavior is manifested annually”.

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Specifically, we use a (quasi) Brownian Motion.\(^9\) This approach seems attractive since firms’ decision whether to cooperate is induced by discrete structural changes of the fundamentals. As we saw above, in some models conduct depends on the state of demand.\(^10\) These structural changes affect the moments of the underlying distribution that govern the stochastic process of the fundamentals. Thus, it seems very reasonable that these structural changes which are triggered by the fundamentals is the triggering mechanism for the change in (oligopolistic) behavior. In accordance with this notion, we adopt the following criterion for the decomposition: that part of price-dynamics which is linearly related to the univariate representation of the fundamentals is defined as the Cournot price equilibrium. Deviations from this equilibrium are defined as oligopolistic dynamics.

3. The model and Decomposition Methodology

Our goal is to model price evolution in an imperfect competitive industry in which firms can periodically resort to cooperative and non-cooperative forms of conduct. This conduct of switching between regimes is referred to as “oligopolistic dynamics”.

Consider for this purpose the following conduct of a typical imperfect competitive firm\(i\) operating in a \(J\) firms industry, \(i = 1, ..., J\):

Let \(p = P(Y(h))\) be the indirect demand for the industry product, where \(p\), \(Y\), and \(h\) are the price of the product, the total quantity demanded and a vector of factors effecting the demand, respectively. Noting that \(Y = \sum y_j\), we total-differentiate the indirect demand with respect to some \(h \in h\) and get

\[
\frac{dp}{dh} = \frac{dp}{dy} \sum_j \frac{dY}{dy_j} \frac{dy_j}{dh} \frac{1}{h} \frac{dY}{dY} = \eta_{yh} \frac{1}{h} \frac{dp}{dY} Y \tag{3.1}
\]

where \(\eta_{yh}\) is defined as the elasticity of the total quantity demanded with respect to

\(^9\)Krugman (1991) and Svensson (1991) use this technique to model exchange rate dynamics.

\(^{10}\)In Chevalier, Kashyap, and Rossi (2000), supermarkets decisions regarding the type of goods to advertise (and commit to a low price) depends on the states of demand and consumers reservation price in each of the states.
In order to maximize its profits, firm \( i \) chooses its production in accordance with the following first-order condition:

\[
p + \frac{dp}{dY} \sum_j \frac{dY}{dy_j} y_i - \frac{dc(y_i, \mathbf{w})}{dy_i} = 0 \tag{3.2}
\]

where \( c(y_i, \mathbf{w}) \) is the cost function depended on the quantity demanded and a vector of input prices, \( \mathbf{w} \). Next we let \( \theta_i \) be defined by

\[
\theta_i \equiv \sum_{j \neq i} \frac{dY}{dy_j} y_i \sum_{j \neq i} \frac{dy_j}{dy_i} Y_{ij} \tag{3.3}
\]

where \( \theta_i \) measures the elasticity of the total reaction of other firms (all \( j \neq i \)) to the choice of firm \( i \)'s quantity supplied. Combining (3.1) - (3.3) and rearranging terms yield the following pricing function:

\[
p = \frac{dc}{dy_i}(y_i(\mathbf{h}), \mathbf{w}) - \frac{1}{\eta_{yh}} \frac{y_i}{Y} \frac{dp}{d \log h} - \theta_i \frac{1}{\eta_{yh}} \frac{dp}{d \log h} \tag{3.4}
\]

Consistently with our definition, the oligopolistic dynamics are embedded in the terms \( \frac{dy_j}{dy_i}, j \neq i \), which appear in (3.4) only in \( \theta_i \). We define a univariate representation of the vectors of demand (\( \mathbf{h} \)) and supply (\( \mathbf{w} \)) fundamentals, affecting the industry price as follows:

\[
f(\mathbf{h}, \mathbf{w}) \equiv \frac{dc}{dy_i}(y_i(\mathbf{h}), \mathbf{w}) - \frac{1}{\eta_{yh}} \frac{y_i}{Y} \frac{dp}{d \log h} \tag{3.5}
\]

which excludes the oligopolistic dynamics. Indeed, for a perfect competitive firm, the second term on the RHS of (3.4) is nonexistent since \( \theta_i = 0 \), but for all other types of firms it is not necessarily nonzero. However, absence of oligopolistic dynamics are not necessarily an outcome of only perfect competition, e.g. a Cournot industry.

Given (3.4) and (3.5), we now account for uncertainty by adding demand and supply disturbances that are unknown or unobservable at time \( t \) but are all with
known probabilities. These disturbances appear in the vectors $h$ and $w$. Substituting from (3.5) into (3.4), appending time subscripts and taking account of uncertainty, results in the following pricing function:

$$p_t = E_t f(z_t) + \beta_i E_t \left\{ \frac{dp}{d \log h} \right\}$$

(3.6)

where $\beta_i = -\theta_i \frac{1}{\eta_i}$, and $z_t = \{h_t, w_t, \gamma_t\}$ is a vector of fundamentals which includes a reduced form disturbance $\gamma_t$ representing demand and supply disturbances. $E_t$ is the expectation operator based on information known up to time $t$.

Although it is efficient for firms to react merely to price changes that originated in the demand factors $h$, $\frac{dp}{d \log h}$, many times they can not extract the original shock and bound to react to price changes that come about from any disturbance, demand or supply. Therefore, in the spirit of the price trigger strategy of Flood and Garber (1983), we replace $\frac{dp}{d \log h}$ with $\frac{dp}{df(z)}$ and consider the pricing function\textsuperscript{11}:

$$p_t = E_t f(z_t) + \beta_i E_t \left\{ \frac{dp}{df(z)} \right\}$$

(3.7)

Note that if there are no oligopolistic dynamics and $\theta_i = 0$, we have $\beta_i = 0$ and consequently, $\frac{dp}{df}$ is a constant equals unity (see (3.7)). However, if there are oligopolistic dynamics, $\frac{dp}{df}$ can not remains constant since firms react to the choices made by firm $i$ upon developments in the fundamentals. This notion is indeed captured in the pricing function (3.7).

In what follows, we assume standard properties regarding the stochastic process governing the univariate random variable representation of the fundamentals $f$. Utilizing these properties enables us to separate out or decompose the process of the expected price change into two components: (i) the expected change emanating from changes in the fundamentals and, (ii) the expected change due to oligopolistic dynamics.

\textsuperscript{11}See Geroski (1992) for application in which prices respond to cost and demand shocks.
A firm’s decision whether to resort to oligopolistic dynamics is usually affected by discrete structural changes in the fundamentals. Technical change or a change in the exchange rate regime are only two examples of such changes. These structural changes affect the moments of the underlying distribution that govern the random processes of the fundamentals. We accordingly assume that \( f \) follows a quasi \((\delta, \sigma)\) Brownian Motion (Krugman (1991) and Svensson (1991)), that is:

\[
 f_t = f_0 + \delta t + \sigma x_t, \tag{3.8}
\]

where \( x \) is a quasi Wiener process with:

\[
 E_t \{ x_{t+s} \} = 0 \quad \text{and} \quad E_t \{ x_{t+s} x_t \} = 0 \quad \forall s > 0, \tag{3.9}
\]

and,

\[
 E_t \{ x_{t+s}^2 \} = \begin{cases} 
 s - \frac{\delta^2}{\sigma^2} s^2 & \text{for } 0 \leq s \leq \frac{5\sigma^2}{3} \\
 s & \text{otherwise} 
\end{cases} \tag{3.10}
\]

Following this already well established technique (Pessach and Razin (1994)), we express the price as a function of the fundamentals, \( p = p(f) \). Approximating this relationship by Taylor’s expansion we get:

\[
 p[f_t] = p[f_0] + p_f(f)[f_t - f_0] + .5p_{ff}(f)[f_t - f_0]^2, \tag{3.11}
\]

where \( p_f \) and \( p_{ff} \) are the first and second order partial derivatives of \( p \) with respect to \( f \), respectively. Substituting (3.8) into (3.11), taking expectations and dividing by \( t \), yields, for \( t \) small enough:

\[
 E_0 \left\{ \frac{p[f_t] - p[f_0]}{t - 0} \right\} = p_f[f_t] \delta + .5p_{ff}[f_t] \sigma^2. \tag{3.12}
\]

Taking the limit of (3.12) with respect to \( t \) and substituting it into (3.7) yields the following second order differential equation:

\[
 p(f) = f + \beta\delta p_f + \beta \sigma^2 p_{ff}. \tag{3.13}
\]

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12We say that the process is quasi Brownian because of the definition of the process \( x \), which differs in its second moment from the definition of a Wiener process. However, with zero drift \((\delta = 0)\), \( f \) is a Brownian motion process and \( x \) is a Wiener process. See Svensson (1991) for the application of Brownian motion in the context of exchange rate and interest rate variability, and Dixit (1989), in the context of firms’ entry and exist decisions under uncertainty. Dixit (1989) also discusses alternative pricing functions such as a mean reverting process.
The general solution to (3.13) is:

\[ p(f) = f + \beta \delta + G_1 e^{(\theta_1 f)} + G_2 e^{(\theta_2 f)}, \]  

(3.14)

where \( \theta_1 \) and \( \theta_2 \) are the roots of the following associated second order equation,

\[ \theta^2 + 2 \frac{\delta}{\sigma^2} \theta - \frac{2}{\beta \sigma^2} = 0, \]  

(3.15)

and \( G_1 \) and \( G_2 \) are constants of integration.

The first two terms in (3.14), \( f + \beta \delta \), represent an equilibrium path for the price in terms of the fundamentals, where no oligopolistic dynamics enter the firms’ strategic choice. Notice that at this solution \( dp/df \) is a constant (equals unity) and is well foreseen. In exactly this respect we refer to this solution as the “Cournot equilibrium”. The rest of the right hand side of (3.14), \( G_1 e^{(\theta_1 f)} + G_2 e^{(\theta_2 f)} \), describes the deviations of the price from this Cournot equilibrium. It represents the component of the price which is accounted for by oligopolistic dynamic considerations, including interfirm rivalry.\(^{14}\) This decomposition enables us to empirically observe the dynamic path of both the fundamentals and the oligopolistic components, and will subsequently be employed in the applied model.

4. The Applied Model

In this section we apply the above described model to the financial intermediation sector (known as imperfect competitive industry) in which there are lenders, borrowers, and financial intermediaries. Individuals supply deposits in accordance with their savings and transaction activities. The reduced-form supply is thus:

\[ DEP^{s}_t = a_0 + a_1(y_t - pop_t) + a_2 r_{dt} + a_3 r_{mt} + a_4 r_{ft} + a_5 e_t + a_6 \pi_t + a_7 \sigma + \mu_t, \]  

(4.1)

where \( DEP^{s}_t \) is the public’s supply of deposits, \( y \) is the index of leading indicators of economic activity, and \( pop \) is population. \( y - pop \) captures the per-capita indicator

\(^{13}\)See Appendix A for derivation.

\(^{14}\)The fundamentals consist of variables which are non-firm specific. Therefore, these variables do not display information on interfirm rivalry.
of economic activity, \( r_d \) is the real interest on deposits representing the real return on deposits, and \( r_m \) is the nominal interest rate on monetary loans as determined by the central bank. \( r_f \) is the dollar libor rate, \( e \) is the rate of change of the real exchange rate, \( pi \) is rate of change of the consumer price index representing the rate of inflation, \( sigma \) is a measure of inflation uncertainty and \( \mu \) is the supply disturbance. The coefficients \( a_1, a_2, \) and \( a_3 \) are expected to be positive. \( a_4, a_5, a_6, \) and \( a_7 \) are expected to be negative. The \( y \) appears in the equation to capture wealth and transaction motives. \( r_m \) represents preferences for short-term deposits in case of a contractionary policy and vice versa. The libor \( r_f \) as well as the change in real exchange rate \( e \) capture the substitution effect.

Borrowers form their demand for credit (of which the financial intermediaries are the suppliers) from their earning prospects, wealth and transaction activities. The reduced-form demand is:

\[
CR_d^t = b_0 + b_1(y_t - pop) + b_2r_c + b_3r_f + b_4e_t + b_5pi + b_6sigma + v_t, \tag{4.2}
\]

where \( CR_d^t \) is the public’s demand for credit, \( r_c \) is the real interest on credit, and \( v \) is the demand disturbance. The coefficients \( b_1, b_3, b_4 \) and \( b_6 \) are expected to be positive and \( b_2 \) is expected to be negative. The sign of the \( b_5 \) coefficient is undetermined.

Each financial intermediary \( j, j = 1, ..., J \) accepts deposits, \( dep_j \) at the going market rate and supplies credit, \( cr_j \), such that its profit is maximized. We assume imperfect competitive financial markets for credit. In equilibrium we have:

\[
dep_{jt} = dep^*_j \quad \text{and} \quad cr_{jt} = cr^d_{jt}, \quad \forall j, t \tag{4.3}
\]

where

\[
\sum_j dep^*_j = DEP^*_t \quad \text{and} \quad \sum_j cr^d_{jt} = CR^d_t, \quad t = 1, 2, ...
\]

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15 An increase in \( e \) represents a devaluation of the local currency vis. a vis. the US dollar.
16 Risk averse customers reduce the demand for unindexed credit in a response to increasing inflation however, the substitution effect would dictate an increase in demand since credit is cheaper.
17 The law of motion, described later in the paper, is such that maximizing contemporaneous profits is compatible with the maximization of the infinite sum of the discounted present and future profits. Thus, no time inconsistency exist in that respect.
18 We specify deposits as an input in the usual manner.
and a constraint that relates the quantity of loans extended, $cr_{jt}$, to the quantity of deposits received, $dep_{jt}$, for each bank such that,

$$cr_{jt} = \alpha \cdot dep_{jt} \quad with \quad 0 < \alpha < 1,$$

(4.4)

where $\alpha$ is exogenously determined by authorities.19

In line with our model the pricing of credit depends, among other things, on the degree of competition in the market for intermediation. As noted above, we deal with an oligopolistic financial intermediation industry, where the intermediary potentially takes account of its rivals’ reaction to its own choice. Therefore, the amount of credit granted by a bank and its pricing are determined by the public’s borrowing needs and the bank’s operating costs, as well as by the expected rivals counteractions. For example, *ceteris paribus*, the larger is the expected extent of the rivals reaction (i.e., the greater the perceived elasticity of the credit demand curve facing the bank), the smaller will be the expansion of the bank’s supply of credit in reaction to demand shock and the larger will be the increase in the credit interest rate.

The price of a financial intermediary is conventionally measured by the financial spread $s$ defined as:20

$$s_t = r_{ct} - \frac{1}{\alpha} r_{dt} + \frac{1 - \alpha}{\alpha} r,$$

(4.5)

where $r$ is the real yield on the required reserves held with the central bank. In our sample period, the central bank paid a constant zero nominal yield on the required reserve balances, therefore the real yield $r$ equals $-\frac{p_t}{1+p_t}$ where $p_t$ is the rate of inflation.

The vector of fundamentals $z$ in this application is:

$$z = \{w, r_m, y, \alpha, r_f, e, pop, p_t, \gamma\}$$

(4.6)

19Note that $\alpha = 1/(1 - rr)$ with $rr$ being the reserve requirement.
20To arrive at the markup, marginal operating costs have to be deducted from $s$. 

13
where \( \mathbf{w} \) is a vector of (physical) input prices,\(^{21}\) and \( \gamma \) being the reduced-form disturbance of \( \mu, v \). In accordance with (3.7) we get the following financial spread evolution:

\[
s_t = f_t + \beta E_t \{ ds_t \}, \tag{4.7}
\]

where

\[
f_t = \psi_0 + \psi_1 (y_t - \text{pop}) + \psi_2 r_{m_t} + \psi_3 r_{f_t} + \psi_4 w_t + \psi_5 \alpha + \psi_6 e + \psi_7 \pi + \psi_8 \sigma + \gamma_t, \tag{4.8}
\]

and \( ds_t \) is measured by discrete changes over time. The core of our econometric application is equation (4.7) which is estimated in the ensuing section.

### 5. Empirical Methodology and Results

We begin the empirical work with the estimation of equation (4.7), which is the reduced form of the model presented in the previous section. With the estimated coefficients we proceed to compute \( \delta \) and \( \sigma \), using (3.8)-(3.10) where:

\[
\delta = E_t \{ f_{t+1} - f_t \} \quad \text{and} \quad \sigma^2 = \delta^2 + \text{var} \{ f_{t+1} - f_t \}. \tag{5.1}
\]

For demonstration we utilize quarterly data from the Israeli banking sector for the 1993.4 – 2004.1 period. Summary statistics appear in Table 5.1.

Specifically, for the interest rate spread (4.5) we use the interest rate charged on short-term loans and the interest rate paid on short-term deposits. Interest rates were modified to account for the time-variant reserve requirements (see equation (4.4)). For the fundamentals we use quarterly data where all quantity data are in constant prices.

\(^{21}\)Like Hall (1988) we make no parametric assumption about the cost function, and use the wage rate (which accounts for over 75% of costs) as a summary statistic for marginal cost. Bils (1987) uses marginal wage cost as a proxy for marginal cost in his study of cyclical behavior of marginal cost and price.
Table 5.1: Summary statistics.

<table>
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<th>Variable</th>
<th>Mean</th>
<th>Max.</th>
<th>Min.</th>
<th>Std. Dev.</th>
<th>Obs.</th>
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<tr>
<td>rm</td>
<td>0.114</td>
<td>0.184</td>
<td>0.042</td>
<td>0.036</td>
<td>42</td>
</tr>
<tr>
<td>w</td>
<td>6,366</td>
<td>7,225</td>
<td>5,635</td>
<td>417.7</td>
<td>42</td>
</tr>
<tr>
<td>α</td>
<td>0.062</td>
<td>0.08</td>
<td>0.06</td>
<td>0.007</td>
<td>42</td>
</tr>
<tr>
<td>rf</td>
<td>0.041</td>
<td>0.067</td>
<td>0.011</td>
<td>0.016</td>
<td>42</td>
</tr>
<tr>
<td>pi</td>
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<td>0.145</td>
<td>−0.027</td>
<td>0.047</td>
<td>42</td>
</tr>
<tr>
<td>e</td>
<td>−0.011</td>
<td>0.113</td>
<td>−0.111</td>
<td>0.054</td>
<td>42</td>
</tr>
<tr>
<td>sigma</td>
<td>0.0006</td>
<td>0.002</td>
<td>0.000</td>
<td>0.0004</td>
<td>42</td>
</tr>
</tbody>
</table>

$s =$ Spread as defined in section 4. $y =$ Index of leading indicators of economic activity. In the long-run regression $y = \ln(\text{index})$. $gap =$ As defined in section 4 (percents). $pop = \ln(\text{population})$ (in thousands). $rm =$ As defined in section 4. $w =$ real wage (in constant prices). In the long-run regression $w = \ln(\text{wage})$. $\alpha =$ Average reserve requirement on commercial banking short-run deposits. $rf =$ As defined in Section 4. $pi =$ The last 4 quarters change in the consumer price index. $e =$ The real exchange rate of the Israeli Shekel against the U.S. Dollar. In the long-run regression $e = (1 + ee)/(1 + pi) − 1$, where $ee$ and $pi$ are the quarterly change in exchange rate and the CPI, respectively. The source: The Bank of Israel Annual Reports.

It is important to note that our methodology requires the estimation of the coefficient $\beta$ in equation (4.7). Since this coefficient is a measure of the sensitivity of the spread with respect to its expected future change, one needs to specify the process of expectation formation. One way is to employ the error correction model (ECM) which allows to relate short-run pricing to deviations from long-run equilibrium. Thus, the ECM, is consistent with cases where firms when making pricing decisions take account of the industry price deviations from the path that would have been determined by the fundamentals such as the Cournot path.

The estimation of the ECM is carried out in two stages: first the long-run equation is estimated, and in the second stage, deviations from long-run equilibrium are incorporated in the short-run relationship. Long-run (steady state) equilibrium in
our model is characterized by constant conduct strategies, that is, $\beta$ in (4.7) is zero. Thus, our estimated long-run relationship in the ECM is:

$$\hat{s}_t = \hat{f}_t. \quad (5.2)$$

where $\hat{\cdot}$ denote estimated values.

The implied estimated short-run relationship is:

$$\frac{ds_t}{dt} = \frac{df_t}{dt} - \xi (s_{t-1} - \hat{s}_{t-1}) + \omega_t, \quad \xi > 0 \quad (5.3)$$

where $s_{t-1} - \hat{s}_{t-1}$ is the error-correction term, and where $\omega_t$ is a white noise residual. Rearranging (5.3), rolling forward one period and substituting from (5.2), we get:

$$s_t = \hat{f}_t + \frac{1}{\xi} E_t \left\{ \frac{df}{d(t+1)} \right\} + \frac{1}{\xi} E_t \left\{ \omega_{t+1} \right\} - \frac{1}{\xi} E_t \left\{ \frac{ds}{d(t+1)} \right\}, \quad (5.4)$$

or,

$$s_t = F_t - \frac{1}{\xi} E_t \left\{ \frac{ds}{d(t+1)} \right\} + \frac{1}{\xi} E_t \left\{ \omega_{t+1} \right\}, \quad (5.5)$$

where,

$$F_t \equiv \hat{f}_t + \frac{1}{\xi} E_t \left\{ \frac{df}{d(t+1)} \right\}. \quad (5.6)$$

Equation (5.5) is the estimated form of equation (4.7) from which we derive the following: (i) $F_t$ is the relevant univariate representation of the fundamentals, which is governed by the assumed Brownian stochastic process (Cf. section 3); (ii) the coefficient $1/\xi$ is the estimated value for $\beta$ in (4.7). Given (i) and (ii), and in accordance with (5.1) we get the estimated values for $\delta$ and $\sigma$.\footnote{Note that we allow for nonlinearities between the fundamentals and the process $F_t$ via the second term in (5.6).}

Estimation results are summarized in Table 5.2. All variables (excluding the structural variable $\alpha$) appearing in the long-run equation were found to be non-stationary ($I(1)$) using the Augmented Dickey-Fuller Unit Root Test. All these variables were found to be cointegrated as well, using the Johansen Cointegration\footnote{Note that in the calculation of $\delta$ and $\sigma$, according to eq. (5.1), we appropriately substitute $f_t$ with the time path $F_t$.}
Test. Accordingly, the residual resl variable is stationary as was confirmed by the unit-root test.

Note that the interest rate parity condition imposes a restriction on the explanatory variables in the long-run equation. In particular, the following relationship holds: \( \log(1 + r_m) = \log(1 + r_f) + \log(1 + e) + \log(1 + \pi_i) \). Therefore, \( e \) was excluded from the long-run equation and appears only in the short-run equation where deviation from interest rate parity exist. In order to capture business cycles effects we add the output gap, \( \text{gap} \), (with a 4 quarters lag) as an explanatory variable in the short-run equation.\(^{24}\) The inflation uncertainty \( \sigma \) appears also only in the short-run equation and is computed as a 4-quarters moving average of the sum of squared deviations of the expected inflation from the actual inflation.\(^{25}\). In the short-run equation the coefficient of the error-correction term \( \text{resl}(-1) \) is negative, less than unity and statistically significant as should be.

The estimated reduced form is:

\[
s_t = F_t - 3.2E_t \{ds/dt\}
\]

which is a stochastic differential equation. The solution for this equation is described below. The parameter estimates give rise to the following derived values (see definitions in (5.1)):

\[
\beta = -3.2, \quad \delta = -0.007, \quad \sigma^2 = 0.018.
\]

With these results, the roots of the quadratic equation (3.15) are complex numbers. Therefore, we derive the polaric coordinates \( \lambda \) and \( \phi \), (see appendix) which are the parameters of the solution \( s(F) \) and get:

\[
s(F_t) = F_t + 0.0225 + 2\pi_1(\lambda)^F_tcos(\phi F_t + \pi_2) + \varphi_t,
\]

\(^{24}\)The data on the output gap are deviations of the potential GDP from the actual GDP. The former was constructed using an estimated GDP production function for the Israeli economy.

\(^{25}\)Computed data on the expected inflation in Israel are available from the capital market, where non-linked government bonds and inflation-linked government bonds with the same maturities are traded simultaneously.
Table 5.2: Interest rate spread: ECM regression results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Long-run (levels)</th>
<th>Short-run (1st diff.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>const.</td>
<td>-0.561</td>
<td>-0.278</td>
</tr>
<tr>
<td>α</td>
<td>-3.905</td>
<td>-3.613</td>
</tr>
<tr>
<td>y − pop</td>
<td>0.512</td>
<td>2.109</td>
</tr>
<tr>
<td>π</td>
<td>0.949</td>
<td>4.115</td>
</tr>
<tr>
<td>rf</td>
<td>-1.246</td>
<td>-1.669</td>
</tr>
<tr>
<td>rm</td>
<td>0.527</td>
<td>2.113</td>
</tr>
<tr>
<td>w</td>
<td>0.056</td>
<td>0.306</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| adj.R²   | 0.855       |          |       | adj.R²      | 0.771       |          |       |
| D.W.     | 1.212       |          |       | D.W.        | 2.168       |          |       |

y and w are in logs. D is a dummy variable = 1 for the 1997.1 period and onward, representing the regime of reduced intervention by the central bank in the foreign exchange market. resl is the residual from the long-run equation. The variables π, rf, rm and e are measured by the log transformation of 1 + ∆ where ∆ is the rate of change of the respective variable. Logarithmic transformation was applied to all explanatory variables. Note, determination of lags was done according to the conventional F test.

where πi, i = 1, 2 are the equation parameters (coefficients of integration) and ϕ is white noise.

We now proceed to the second stage of the estimation, where we apply nonlinear estimation methodology in order to estimate the coefficients of integration in (5.8). For this estimation we utilize a Non-Linear-Least-Square technique, using the Marquardt algorithm, (Pindyck and Rubinfeld (1991)). The estimated parameters appear in Table 5.3:

We now have the complete representation of the solution to the stochastic differential equation of the interest rate spread:

\[ s(F_t) = F_t + 0.0225 - 0.38(\lambda)^F_t \cos(\phi F_t - 0.256)) + \varphi_t. \]

The solution is now decomposed as follows:
Table 5.3: Interest rate spread: second stage non-linear estimation.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-stat.</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_1$</td>
<td>-0.190</td>
<td>-6.321</td>
<td>0.00</td>
</tr>
<tr>
<td>$\pi_2$</td>
<td>-0.256</td>
<td>-1.978</td>
<td>0.05</td>
</tr>
<tr>
<td>$adj.R^2$</td>
<td></td>
<td>0.632</td>
<td></td>
</tr>
</tbody>
</table>

(i) $sc(F_t) = F_t + 0.0255$ is the “Cournot equilibrium” path of the interest rate spread.

(ii) $sdev(F_t) = -0.38(\lambda)^{F_t}\cos(\phi F_t - 0.256)$ represents the deviations of the spread (from the “Cournot path”) to which oligopolistic dynamics are responsible.

In Figure 1, we present the solution for the oligopolistic dynamics (conduct) $sdev(F)$, indicating the exercise of these dynamics by banks in the Israeli financial markets. The 0.00 line represents the “Cournot” equilibrium path and $sdev(F)$ is deviations from this equilibrium path and hence represents the path of oligopolistic dynamics. At the beginning of our sample-period (1994), this solution indicates enhanced competition (the path is below the 0.00 line). However, toward the end of 1996, the path crosses the 0.00 line and stays more or less above it for almost throughout the period (with the exception of two short episodes of significant capital market instability - centered around the fourth quarter of 1998 and the first quarter of 2002), indicating that competition had been softened due to oligopolistic dynamics.

Although this entire exercise is designed merely to demonstrate the application of the decomposition methodology, it is worth noting some major events that seem to have brought about some of the more pronounced deviations displayed in Figure 1. However, before describing these developments, we need to make the following clarification: these developments (described below) are clearly fundamentals and thus are included as explanatory variables in the short-run regression. The decomposition separates out their “demand and supply” effects from their effect on firms’
conducts. The display in Figure .1 indicates the latter effect.

We start off with the effect of the massive inflow of immigrants to Israel, beginning in the late 1989 and lasting (in high rates of immigration) for at least up to 1995 and is well noticeable in the figure. This development triggered financial intermediaries to enhance competition in order to attract immigrants’ funds and new clientele, all of which resulted in a lower interest spread. Also in that period of time Israel undertook significant liberalization measures in the foreign exchange market and in particular, the gradual alleviation of restrictions on direct foreign borrowing and lending. Local banks found themselves competing with foreign financial intermediaries in addition to their local rivals. This had also contributed to the narrowing of the interest rate spread. In the second half of the decade, the government implemented a contractionary monetary and fiscal policies and there developed an inflow of foreign exchange into the country. Banks, being the main link of these foreign capital movements, may have used this opportunity to enhance their profits by resorting to oligopolistic conduct.

As noted above, the interest rate spread is decomposed into the time path $sc(F)$, which is governed by the dynamics of fundamentals and involves no oligopolistic dynamics, and to the time path $sdev(F)$, which comprises deviations of the spread due to oligopolistic dynamics. The time series of these paths as well as the spread itself $s(F_t)$ are depicted in Figure .2. There are two purposes for this display: first, it allows one to compare the relative magnitude of the deviations by comparing $sc(F)$ to $s(F)$. The actual interest rate spread is on average 10 times larger than the deviation of the spread from the “Cournot” equilibrium (note the dual scaling in Figure .2). Secondly, in order to gain some intuition for the difference, and perhaps the misleading results that can arise from not filtering out fundamentals from oligopolistic dynamics, it can be seen (Figure .2) that while our solution $sdev(F)$ points to a conduct of decreasing competition, in particular in the second half of the decade, the conventional spread $s(F)$, points to dynamics of enhanced competition.
The difference between these two dynamic solutions results from the time path of the fundamentals.

6. Summary

This paper presents a methodology for the decomposition of the dynamics of economic rents such that the impact of both oligopolistic dynamics and the dynamics of fundamentals on marginal profits can be observed. Applying this procedure to the Israeli banking sector enabled us to single out periods during which competition among banks was either intensified or mitigated (relative to the Cournot equilibrium) due to oligopolistic dynamics. Results indicate a substantially different conduct once fundamentals are filtered out. If price rigidity is to exist during periods of weaker competition due to, e.g., reasons of cooperation, then we provide a tool that can be of assistance in tracking it empirically.
A. Derivation of the Differential Equation

In this appendix we derive the dynamic solution for the oligopolistic price from the specified differential equation (3.13) in the text. For convenience we rewrite this equation as,

\[ p(f) = f + \beta \delta p_f + 0.5 \beta \sigma^2 p_{ff} \]  
(A.1)

Applying the standard way of solving differential equations, we seek two solutions: one specific solution to (A.1) and another solution to the homogeneous part of equation (A.1).

(i) For the specific solution we have,

\[ p(f) = f + \beta \delta \]  
(A.2)

(ii) For the homogeneous equation \( p(f) = \beta \delta p_f + 0.5 \beta \sigma^2 p_{ff} \) we have,

\[ p(f) = G_1 e^{(\theta_1 f)} + G_2 e^{(\theta_2 f)} \]  
(A.3)

were \( \theta_1 \) and \( \theta_2 \) are the roots of the second order equation,

\[ \theta^2 + 2 \frac{\delta}{\sigma^2} \theta - \frac{2}{\beta \sigma^2} = 0 \]  
(A.4)

We now combine (A.2) and (A.3) to get the solution (3.14) in the text.

In case where (A.4) has complex roots we define \( \lambda \) and \( \phi \) such that,

\[ \lambda = e^{-\left(\frac{\delta}{\sigma^2}\right)} \]  
(A.5)

and,

\[ \phi = \left( \frac{\delta^2}{\sigma^4} - \frac{2}{\beta \sigma^2} \right)^{1/2} \]  
(A.6)

Notice that we also have,

\[ \theta = \lambda e^{\pm i\phi} = \lambda (\cos(\phi) \pm i \sin(\phi)) \]  
(A.7)
Next, we let the constants of integration be $G_1 = \pi_1e^{i\pi_2}$, and $G_2 = \pi_1e^{-i\pi_2}$.

Substituting these transformations into (A.3) yields the following:

$$p(f) = f + \beta\delta + 2\pi_1\lambda f \cos(\phi f + \pi_2)$$  \hspace{1cm} (A.8)

where $\pi_1$ and $\pi_2$ replace the constants of integration $G_1$ and $G_2$. 
References


Figure 1: Deviations of the interest rate spread ($sdev$) from a "Cournot" Equilibrium, for years 1993Q4—2004Q1.
Figure 2: The values of the interest rate spread (bold line), and the “Cournot” spread (dotted line) are depicted (in logarithmic terms) using the left vertical axis. The deviations from “Cournot” Equilibrium is depicted using the right vertical axis. All values are in percentage points, for the period 1993Q4 -2004Q1.