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Sticky prices, competition and the Phillips curve

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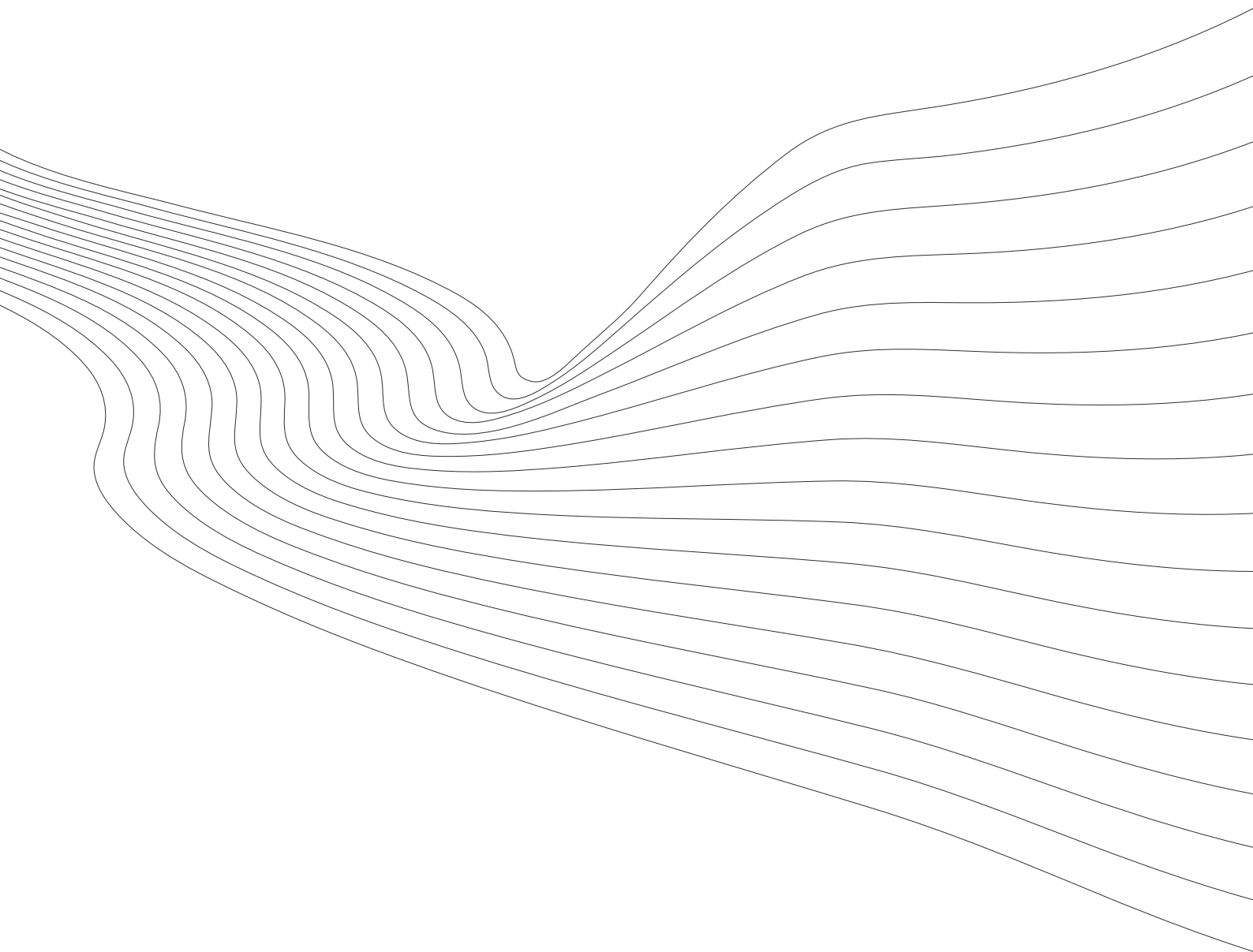
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KOF Working Papers

Sticky Prices, Competition and the Phillips Curve

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Abstract

This study analyzes how competition affects price stickiness at the micro level. On the theoretical side, I develop what I call a micro Phillips curve, i.e. a product-specific relation between inflation and economic activity conditional on inflation expectations. I find two opposing effects of competition on the slope of the micro Phillips curve. On the one hand, stronger competition leads to a higher frequency of price revaluations, implying a steeper slope. On the other hand, the stronger competition is, the less firms can transmit changes in economic activity into price changes, implying a flatter slope. Using unique product-level manufacturing panel data, I find that the latter effect clearly dominates and plays an important role in explaining price stickiness. The effect of a marginal increase in economic activity on the likelihood of a price increase is between 63% and 85% lower for products, that face very strong competition, compared to products, that face very weak competition. In line with the theory, prices of products, that face very strong competition, are also less likely to *decrease* in response to marginal *decreases* in economic activity. Moreover, it heavily depends on the degree of competition that a product faces whether, and to what extent, the micro Phillips curve is non-linear. The stronger the competition the weaker will be the non-linearity of the micro Phillips curve. My findings imply that effective business cycle policy necessitates good competition policy. Reforms which strengthen the competition in an economy will make stimulus or stabilization policy more effective. Furthermore, the results imply that stimulus or stabilization measures, that target specifically high competition firms or sectors, may be more effective than programs, that follow an indiscriminate all-round principle.

JEL codes: E31, E32

Keywords: Price stickiness, Phillips curve, real rigidity, micro data

1 Introduction

Are prices sticky? If so, why are prices sticky? What determines how sticky prices are? The last years have witnessed a lot of research on these questions. The issue of price stickiness, rigidity or flexibility has always been at the heart of macroeconomics. After all, this very issue is at the root of the great divide between (neo)classical and (new) Keynesian economics. Thus, why is the topic so crucial? It is because the degree, to which prices are sticky, determines how neutral money is with respect to real outcomes like output and employment. The implications of this statement are large: if money is indeed not neutral, we enter a world of economic thinking which is totally different to the world of money neutrality. Our theories and also our policy advice will be radically different; even our research interests will be quite different. Actually, most contemporary macroeconomic models assume that money is *partly* neutral, hence, they combine both worlds of economic thinking. This may hide sometimes, what a big difference it makes to assume that money is not neutral, instead of assuming money neutrality. Somewhat ironically, the difference becomes more apparent from undergraduate textbooks, since these books usually distinguish sharply between a world of flexible prices and a world of fixed prices. On the policy side, the degree of price stickiness determines how successful policy makers can be in stimulating or stabilizing the business cycle. The less flexible prices are, the more will stimulus measures have real effects instead of just resulting in higher inflation. In contrast, the more flexible prices are, the more will the business cycle rest on forces that we cannot influence – at least not by means of ad hoc stimulus or stabilization policy. To be concrete, the degree of price stickiness decides about how many people will loose their job when the world economy goes down, how strongly a banking crisis will affect the real economy, to what extent the government can create an artificial boom in order to win the next election etc. The Phillips curve is closely related to the issue of price stickiness. It tells us, how prices respond to (unexpected) changes in economic activity. For instance, the lower the slope of the Phillips curve, the stickier prices will be in response to changes in economic activity, and the more a nominal stimulus will result in higher real activity instead of higher inflation.¹ Hence, in order to know more about the prospects and limits of business cycle policy, we need to learn what factors determine the slope of the Phillips curve and whether/how we can influence these factors.

This study analyzes theoretically and empirically, how the degree of competition among firms affects price stickiness. On the theoretical side, I develop what I call a micro Phillips curve, i.e. a product-specific relation between inflation, inflation expectations and capacity

¹I follow the literature in referring to the derivative of inflation with respect to (the deviation of) economic activity (from its natural level) as the slope of the Phillips curve. This definition implies that asking about the stickiness of prices in response to changes in economic activity is nothing else than asking about the slope of the Phillips curve.

utilization. This allows me to study – at the product level – how the degree of competition affects the slope of the Phillips curve, i.e. the response of inflation to marginal changes in economic activity, conditional on price expectations. I find two opposing effects of competition on the slope of the Phillips curve. On the one hand, a stronger degree of competition leads to a higher frequency of price revaluations, implying a steeper slope of the Phillips curve. On the other hand, the stronger is the competition, the less pricing power firms have, and the less they can transmit changes in economic activity into price changes, implying a flatter slope of the Phillips curve. On the empirical side, I find that the latter effect clearly dominates and plays an important role in explaining price stickiness. A stronger degree of competition weakens the link between inflation and economic activity substantially. For instance, the effect of a marginal increase in capacity utilization on the probability of a price increase is between 63% and 85% lower for products, that face a very strong degree of competition, compared to products, that face a very weak degree of competition. For products facing very strong competition, the Phillips curve is statistically inexistent. Notably, prices of products, that face very strong competition, are also less likely to *decrease* in response to marginal *decreases* in economic activity. This may seem counterintuitive, but is fully in line with the theory. Moreover, I find that it heavily depends on the degree of competition that a product faces whether, and to what extent, the micro Phillips curve is non-linear. In case of very weak competition, the higher (lower) the level of economic activity already is, the higher will be the likelihood of a price increase (decrease) in response to marginal increases (decreases) in economic activity. This pattern gets weakened, when a product faces stronger competition. Eventually, for products facing very strong competition, the pattern disappears completely: even in times of an economic boom (downturn), prices do not increase (decrease) in response to marginal increases (decreases) in economic activity.

This study makes a number of contributions.² Although mostly micro-founded, contemporary business cycle models generally study price dynamics at the aggregate level. In recent years, however, more and more authors promote to study price dynamics at a micro level (see Maćkowiak and Smets, 2008, amongst others). The reason for this being the conviction, that the richness and great variation at the micro level will help us to better answer the aforementioned questions, namely (why) are prices sticky, and what determines how sticky prices are.³ Eventually, micro level studies may help to understand what factors determine how neutral money is with respect to real outcomes and how

²Each strand of literature mentioned in the following will be reviewed more extensively in Section 2.

³In fact, there is ample empirical evidence that price stickiness and competitive pressure varies greatly across firms or products even within one sector. In contrast, contemporary business cycle models generally assume that all firms in the economy are identical including the assumption that all firms face the same degree of competition. At least, some models assume that the degree of competition, that a firm faces, is a function of the firm's relative market share. It can be doubted, whether this assumption is fully convincing.

successful policy makers can be in stimulating or stabilizing the business cycle. Once we know these factors, we may also know whether/how we can influence them to improve the effectiveness of business cycle policy. Following this route, I study the competition among firms as one factor of price stickiness. Specifically, I develop a Phillips curve at the micro level, i.e. a product-specific relation between inflation, inflation expectations and capacity utilization. On this basis, I analyze theoretically and empirically, how the individual degree of competition that a product faces affects the slope of the micro Phillips curve. Throughout the study, I refrain from aggregation. Still, my findings allow me to draw general conclusions. The degree of competition in an economy matters substantially for how sticky prices are in response to changes in economic activity. The higher the degree of competition, the less firms will transmit increases (decreases) in economic activity into price increases (decreases). Consequently, high competition economies will be less prone to inflationary (deflationary) pressures in times of economic boom (downturn). Also, stimulus or stabilization policy will be more successful in high competition economies, compared to low competition economies. The set-up of my study does not allow me to infer concrete inflation figures. Still, my findings suggest, that inflationary pressure – in terms of the likelihood of price increases in response to increases in economic activity – is *ceteris paribus* between 2.7 and 6.9 times stronger in very high competition economies, compared to very low competition economies. In boom times, inflationary pressure is even between 3.3 and 23.4 times stronger. In times of economic downturn, deflationary pressure is between 3.4 and 9.3 times stronger. The results of this study imply that (structural) competition policy and business cycle policy are related to each other. Reforms that strengthen the degree of competition in an economy will make stimulus or stabilization policy more effective. Hence, the policy lesson is that effective business cycle policy necessitates good competition policy. If policy makers want to be successful in stimulating or stabilizing the business cycle, they should engage in structural reforms. Further, the results of this study imply that stimulus or stabilization measures, that target specifically high competition firms or sectors, may be more effective than programs, that follow an indiscriminate all-round principle.

The data used in this study have several favorable features. The literature dealing with disaggregate price data generally lacks information on product-specific price expectations and product-specific economic activity.⁴ Consequently, the empirical Phillips curve literature remains at the aggregate or sectoral level. This study is one among the few (Köberl and Lein, 2009, Lein, 2010 and Gaiotti, 2010), that provides product-specific data on inflation, inflation expectations and economic activity, making it possible to implement

⁴Also, this line of literature employs sector-specific competition measures along with firm-level panel data or firm-specific competition measures along with firm-level cross-section data. The use of only sector-specific competition measures or only cross-section data may explain the often weak results in the literature. In contrast, this study employs all variables on the product level in panel form.

Phillips curve specifications at the micro level. Product-specific data allow to better control for aggregate effects, avoiding problems which are typical for aggregate estimates of the Phillips curve. Also, the use of a direct measure for expected inflation avoids problems the Phillips curve literature usually has to deal with. To the best of my knowledge, this study is the only one that combines product measures of competition with the forementioned Phillips curve variables. This allows me to study – at the product level – the impact of competition on price setting and on the Phillips curve.⁵

In addition to the aforementioned contributions, this study contributes to the literature on globalization, inflation and the Phillips curve. The main argument in this literature is that globalization increases competition which, in turn, reduces firms' ability to raise prices in response to increases in economic activity – implying a flatter slope of the Phillips curve and lower inflation. The literature tests this argument by relating measures of globalization to the Phillips curve and to inflation. In contrast, I test (a part of) the argument more directly by analyzing product-specifically how competition affects the micro Phillips curve. In showing that changes in the degree of competition alter firms' price response to changes in economic activity substantially, I render support for the argument that the increase in market competition is an important channel through which globalization affects inflation. In addition, the study contributes to the micro data price-setting literature. This literature lacks information on product-specific economic activity and determines the degree of price stickiness by the frequency of price adjustments.⁶ The literature generally presumes that higher competition induces lower price stickiness. I show that this presumption is not immediate from a theoretical perspective. On the one hand, the higher the competition, the higher will be the probability that a firm reviews (and adjusts) its price in any given period. On the other hand, assuming Calvo pricing and strategic complementarity, a higher degree of competition will decrease the slope of the Phillips curve, thereby, increasing price inertia. The resulting net effect is not clear. My empirical set-up allows to separate the two channels. I find that, while firms facing higher competition change prices indeed *more frequently overall*, their prices respond *less frequently to changes in economic activity*. Finally, this study contributes to the literature on non-linearity of the Phillips curve. As described above, the weaker is the degree of competition a product faces the stronger will be the non-linearity of the micro Phillips curve.

⁵In addition, the study employs transaction prices instead of list prices. Transaction prices are generally preferred to list prices, because the former are actually realized. Further, the study uses Swiss data. Switzerland is an excellent place for a micro-level panel data study on price stickiness, because stable and low aggregate inflation, steady monetary policy and stable aggregate economic conditions provide an ideal setting for analyzing diversity on the disaggregate level.

⁶There do exist micro data price-setting studies, which have information on product-specific economic activity. However, these studies focus on different interesting research questions and do not incorporate data on competition (see Köberl and Lein, 2009 and Lein, 2010, e.g.).

Not every author uses the term price stickiness with exactly the same meaning. This also applies to the term price rigidity. Often, the degree of stickiness of a price refers to how frequently the price changes (see Bils and Klenow, 2004, amongst others). In contrast, some authors mean by price stickiness how often and/or strongly a price changes *in response to certain shocks or in response to certain changes in other variables like demand or costs* (see Maćkowiak and Smets, 2008, amongst others). It is important to clearly distinguish between these meanings, as I show that certain prices are quite sticky in response to changes in economic activity without being sticky overall/unconditionally. Yet other authors refer to the frequency with which a price changes, as the degree of rigidity of the price (see, e.g., Carlton, 1986). Further, the Calvo pricing literature uses the term nominal rigidity to denote the probability, with which a firm reoptimizes prices each period. In contrast, the term real rigidity refers to firm or market characteristics, that make optimal (relative) prices change only relatively little or infrequently over time.⁷ In this study, I use the term price stickiness to denote the frequency of price changes either unconditionally or in response to changes in economic activity. If necessary, I make clear which one of the two alternatives is meant. Furthermore, I use the term rigidity in line with the Calvo pricing literature. Notably, the degree of price competition among products is one source of real rigidity, and a higher degree of price competition implies a higher price elasticity of demand and higher strategic complementarity between products.

The remainder of the study is structured as follows. Section 2 reviews the literature related to this study. Section 3 develops a theory on how the degree of price competition, which a product faces, determines the slope of the micro Phillips curve. Section 4 describes the data and the econometric model employed in this study and presents summary statistics. Sections 5 and 6 present empirical results and robustness tests. Finally, Section 7 concludes.

2 Literature review

This study relates to several strands of literature. To begin with, the study is linked to the New Keynesian Business Cycle (NKBC) literature which considers the degree of competition among firms as a major determinant of how output and inflation responds to shocks. For one, Woodford (2003, p. 160ff and p. 192f) shows that, when the degree of competition among firms is high, unexpected variations in nominal spending have substantial effects on output, but only little effects on inflation. Importantly, this result

⁷Firms facing strong real rigidity may change (relative) prices only slightly and infrequently over time even when facing weak nominal rigidity. The term real rigidity was introduced by Ball and Romer (1990). See Woodford (2003, p. 162) for a criticism of the term.

holds even if nominal rigidity is very low, i.e. if a high fraction of firms reoptimizes its prices frequently. Given this result, it seems surprising why the aforementioned literature pays more attention to nominal than to real rigidity. Khan (2005) shows that the slope of the New Keynesian Phillips curve (NKPC) is increasing in the degree of competition among firms when firms set prices according to the Rotemberg (1982) quadratic cost of price adjustment model.⁸ In contrast, the slope of the NKPC is decreasing in the degree of competition among firms when strategic complementarity in pricing decisions prevails and firms set prices according to the Calvo (1983) staggered price setting model. Hence, we learn from Khan that the underlying assumptions about firms' price setting behavior determine how changes in competition affect the NKPC. Further, Andrés *et al.* (2008) show within a two-country monetary union general equilibrium framework that small differences in the degree of competition across countries may be responsible for substantial inflation differentials after monetary policy shocks that represent up to one fifth of the actual inflation dispersion in Euro area countries.

This study differs from the aforementioned literature in the following respects. NKBC models generally assume a continuum of identical firms making it relatively easy to switch from the price optimization of an individual firm to the derivation of the Phillips curve on the aggregate level by using Dixit-Stiglitz, Kimball or related aggregators (see Dixit and Stiglitz, 1977 and Kimball, 1995). In contrast, in Section 3 I derive a firm or even product-specific relation between prices, price expectations and output, which allows studying the response of inflation to changes in economic activity at the micro level. Related to this, NKBC models generally assume that the degree of competition a firm faces is constant across all firms in the economy. It is noteworthy that this assumption is not made deliberately, but is a technical artefact: the assumption has to be made in order to use the Dixit-Stiglitz aggregator which alleviates the aggregation over firms. At least, some NKBC models employ the Kimball or related aggregators which allow for more flexibility: the degree of competition, which a firm faces, then directly depends on the firm's relative market share (see Eichenbaum and Fisher, 2007, Klenow and Willis, 2006, Sbordone, 2007 and Guerrieri *et al.*, 2010 among others). In fact, the degree of competition varies greatly across products even within a sector and does not necessarily depend on a firm's market share. This suggests to allow for a firm- or product-specific degree of competition and to study the relation between competition, prices and output not at the aggregate but at the micro-level. This study follows this route.

Next to the aforementioned literature, this study is related to the literature on the flattening of the Phillips curve in recent decades. A common explanation for this phenomenon is

⁸See also Martin (1993) who finds that the speed of price adjustment depends positively on the price elasticity of demand when assuming quadratic cost of price adjustment.

the change in monetary policy in the early eighties which anchored inflation expectations and reduced trend inflation (see, e.g., Ball, 2006, Mishkin, 2009 and Ihrig *et al.*, 2010). An alternative explanation for the flattening of the Phillips curve relates to economic globalization or trade integration. Sbordone (2007) helps us to identify the role of competition in this field of research by decomposing the effect of economic globalization on the slope of the Phillips curve, i.e. the relation between consumer price inflation and domestic output, into three distinct parts. First, globalization changes the relation between consumer price inflation and domestic inflation, since with increasing trade integration the price dynamics of goods produced abroad becomes relatively more important (see the discussion on the global slack hypothesis in Borio and Filardo, 2007 and Ihrig *et al.*, 2010). Second, globalization affects the relation between domestic inflation and the marginal cost of production. Third, globalization affects the relation between marginal cost of production and domestic output. As regards the second part, the main argument both in academic studies and policy debates is that globalization fosters market competition and, thereby, decreases pricing power of firms (see, e.g., Ball, 2006 and International Monetary Fund, 2006, ch. 3). In this line of research, Auer and Fischer (2010) find for a panel of 325 US manufacturing industries from 1997 to 2006 that a higher share of imports from low wage countries exerts substantial downward pressure on domestic producer prices. Thus, we learn from Auer and Fischer that import competition dampens producer price inflation considerably – at least if the share of imports from low wage countries is a valid proxy for import competition. Employing sector level EU manufacturing data, Chen *et al.* (2009) find that trade openness dampens producer prices at least in the short run, while long run effects are more ambiguous. In line with the aforementioned argument they attribute this result to an increase in – trade openness induced – competitive pressure. To the best of my best knowledge, Gaiotti (2010) is the only paper that studies the effect of globalization on the Phillips curve on a company-level basis. Using yearly data for about 2000 firms from 1988 to 2005, Gaiotti finds that firms’ exposure to globalization does not affect firms’ price response to changes in capacity utilization.

This study contributes to the forecited literature in the following respect. As said, the main argument in the literature is that globalization increases competition which, in turn, reduces firms’ ability to raise prices in response to increases in economic activity – implying a flatter slope of the Phillips curve and resulting in lower prices and lower inflation. The literature tests this argument by relating measures of globalization, trade integration, trade openness and the like to the Phillips curve, to prices or to inflation. In contrast, I test (a part of) the argument more directly by analyzing product-specifically how competition affects the micro Phillips curve and price-setting.⁹

⁹Besides this market channel, Rogoff (2006) argues that globalization enforces competition and thereby reduces central banks’ incentive to inflate the economy. The setting of this study precludes this mecha-

In addition to the aforementioned literature, several authors have studied the relation between competition and the Phillips curve at the aggregate level. An early empirical paper is Duca and VanHoose (2000). Using aggregate US data and employing traditional expectations augmented Phillips curve specifications, the authors find that greater competition has flattened the slope of the Phillips curve during the 1990's.¹⁰ Przybyla and Moreno (2005) explore the link between the degree of product market competition and inflation rates across EU countries and sectors using several alternative proxies for competition (mark-up level, profit margin, profit rate and a survey based “intensity of competition” variable). Their findings suggest that higher product market competition substantially reduces average inflation rates.

Again, this study differs from the forecited literature in that it studies the impact of competition on the Phillips curve and on price-setting (not on the aggregate or sectoral level, but) on the product level. To my mind, a micro level study is worthwhile since the degree of price competition varies greatly across products even within one sector.

Next, this study is related to the empirical micro data literature on price setting. According to this line of literature the frequency of price changes varies greatly across goods and sectors and the degree of competition is a key factor in firms’ pricing strategies.¹¹ In particular, it is argued that firms facing a higher degree of competition will employ pricing strategies which allows them to react more flexibly to changes in market conditions and competitors’ behavior. Consequently, according to this literature, firms facing stronger competitive pressures will adjust their prices more frequently. As regards pricing strategies, Álvarez and Hernando (2007) report, based on coordinated cross-section firm surveys in different Euro area countries, that the share of firms that set prices according to competitors’ prices is higher among firms facing strong competition compared to firms facing low competition. Conversely, the share of firms that set prices according to a markup over costs rule is lower among firms facing strong competition compared to firms facing low competition. As regards the actual frequency of price adjustment, Carlton (1986) examines US product transaction prices from 1957 to 1966 and finds that the level of industry concentration correlates strongly positively with the average spell during which

nism and concentrates on the market channel.

¹⁰See further discussion and cross-country data evidence in Daniels and VanHoose (2006, 2009). See also Romer (1993) and Temple (2005) amongst others on whether trade openness reduces the slope of the Phillips curve.

¹¹See, e.g., Bils and Klenow (2004), Álvarez *et al.* (2006), Álvarez and Hernando (2007). See Fabiani *et al.* (2006) for survey evidence about firm’s price setting behavior in the Euro area, Dhyne *et al.* (2006) for a summary of consumer price micro-data studies and a comparison of Euro area and USA, Vermeulen *et al.* (2007) for a documentation of research on producer price setting conducted within the Eurosystem Inflation Persistence Network (IPN), and Levy and Smets (2010) for a summary of recent studies within the IPN.

prices remain unchanged.¹² Bils and Klenow (2004) employ monthly consumer price data from the U.S. Bureau of Labor Statistics for 1995 to 1997 and find that goods sold in more competitive markets – as measured by inverse concentration ratios, inverse wholesale markups or product turnover rates – display more frequent price changes. However, these results are driven by energy-related goods or fresh food. The competition measures are not product-specific, but can only be identified at the sector level. Given the great variety in competition across goods even within one sector, this is a limitation and may explain why Bils and Klenow’s results with respect to competition are not robust.¹³ Further, Álvarez and Hernando (2007) conduct a Euro area sectoral study based on the aforementioned cross-section surveys and find that the the fraction of firms in a sector, that change prices at least four times per year, is increasing in the degree of competition – as measured by either the importance that firms attribute to competitors’ prices in influencing a reduction in their own prices or by the inverse share of firms that employ a markup over costs pricing rule.^{14,15}

This study contributes to the micro data price-setting literature in the following respects. First, whereas this literature employs sector-specific competition measures along with firm-level panel data or firm-specific competition measures along with firm-level cross-section data, I employ product-specific competition measures along with product-specific

¹²Caucutt *et al.* (1999) study price patterns for US manufactured commodities from January 1982 to July 1994 and confirm Carlton’s result.

¹³Nonetheless, Bils and Klenow (2004) make other important contributions and the relation between competition and price setting is clearly not the main focus of this paper.

¹⁴Aucremanne and Druant support this finding using the Belgian survey only (see Fabiani *et al.*, 2007, ch. 4); Hoerberichts and Stokman support it for the Dutch survey (see Fabiani *et al.*, 2007, ch. 9) and for a new Dutch cross-section firm survey (see Hoerberichts and Stokman, 2010). Hall *et al.* (2000) find for a separate UK survey that companies operating in more competitive markets review and change prices more often. Using an impressive micro data set underlying the construction of the Spanish Producer Price Index from November 1991 to February 1999, Álvarez *et al.* (2010) study the relation between different competition measures and the frequency of price changes. Two indirect competition measures – the degree of import penetration and the relevance attached by firms to demand conditions in explaining prices changes – exhibit a significantly positive effect on the frequency of price decreases, whereas their effect on the frequency of price increases is insignificant. In contrast, a number of direct competition measures – the number of competitors, the inverse of the average mark-up, the inverse of the cumulative share in employment of leading firms as well as inverses of several market concentration measures – never exhibit any significantly positive effect on the frequency of price changes. As in Bils and Klenow (2004) the competition measures are not available at an individual level, but can only be identified at the sector level. Given the great variety in competition across goods even within one sector, this may explain the weak results of Álvarez *et al.* (2010). This notwithstanding, Álvarez *et al.* produce a series of very interesting other results which are not directly related to my study. In remarkable contrast to the aforementioned studies, Coricelli and Horváth (2010) find for Slovakian consumer price data covering 604 products at monthly frequency from 1997 to 2001 that market competition – proxied by the inverse of sectoral price dispersion – tends to increase price persistence and seems to be associated with less frequent price changes.

¹⁵The relationship between market structure and price setting is also studied in industrial economics. See Carlton (1989) for a survey of theoretical and empirical work. I have done my best to take into account the contributions from this field. In fact, some of the scholars cited in this literature review are industrial economists.

panel data. This is a substantial improvement as competition varies greatly across products even within one sector and panel data allow studying price-setting behavior over time. Second, the aforementioned literature studies how the degree of competition affects the degree of price stickiness, where this literature lacks information on product-specific economic activity and determines the degree of price stickiness by the frequency of price adjustments. In contrast, I follow the above-mentioned NKBC literature and focus mainly on how the degree of competition affects the degree of price stickiness, where I determine the degree of price stickiness by how frequently prices adjust *in response to changes in product-specific economic activity*.¹⁶ Third, and related to this: the aforementioned literature presumes that higher competition induces a higher frequency of price changes. As argued by Coricelli and Horváth (2010), this presumption is not obvious from a theoretical perspective. On the one hand, the higher the competition, the higher will be the probability that a firm reviews (and adjusts) its price in any given period. On the other hand, assuming Calvo pricing and strategic complementarity, a higher degree of competition will decrease the slope of the Phillips curve, thereby, increasing price inertia. The resulting net effect is not clear. The empirical set-up of this study allows to separate the two channels. I find that, while firms facing higher competition change prices indeed *more frequently overall*, their prices respond *less frequently to changes in economic activity*. This implies at the aggregate level that inflationary (deflationary) pressures in boom (recession) times are relatively less severe when firms operate in a relatively high competition environment. Furthermore, this implies that policy measures that intend to stimulate economic activity, will be more effective for firms facing relatively high competition because such firms will respond less by rising prices instead of rising production.¹⁷

¹⁶See Section 1 for a discussion on the terms stickiness and rigidity.

¹⁷Some empirical micro data studies analyze how prices respond to changes in demand and costs. These studies have produced rather conflicting results. Geroski (1992) analyzes UK manufacturing data at a sectoral level and finds that prices in less concentrated industries adjust more quickly to changes in demand and costs. Kraft (1995) finds the opposite using German manufacturing data. Using Austrian manufacturing data, Weiss (1993) finds that more concentrated industries adjust prices more quickly in response to changes in demand, but more slowly in response to changes in cost. Bertola *et al.* (2010) analyze a Europe-wide cross-section firm survey which was collected within the framework of the Eurosystem's Wage Dynamics Network; their proxy for the degree of competition is a dummy variable coded as one if the firm indicates that it will be "very likely" to decrease the price of its product if the firm's main competitor reduced its price and coded as zero if the firm indicates "likely", "not likely", "not at all" or "do not know/does not apply". Bertola *et al.* find that firms facing strong competition (in the aforementioned sense) are less likely to indicate that they will increase prices after an unanticipated increase in costs for an intermediate input (=cost shock) or after an unanticipated permanent increase in wages (=wage shock), though this effect is statistically significant only for the wage shock. In contrast, firms that face strong competition are significantly more likely to indicate that they will reduce costs after a cost or wage shock. These results are contrasted by Kwapil *et al.* (2010) who examine an Austrian cross-section firm survey and find that firms with more than five competitors are more likely to indicate that they will change prices quickly after a demand or cost shock.

3 Theory

The following section develops a theory on how the degree of price competition a product faces determines the slope of the micro Phillips curve. Assume the existence of a continuum of firms $I = [0, 1]$. Each firm $i \in I$ produces a single good i .¹⁸ Let Y_{it} denote firm i 's production of the good in period $t = 0, \dots, \infty$. Following Calvo (1983), firm i reevaluates or reoptimizes its sales price P_{it} with probability $1 - \theta_i$ in any given period t . When the firm reoptimizes in period t it chooses the price P_{it}^* that maximizes the present expected value of future profits generated when P_{it}^* is effective under the constraint that its supply or production equals demand in each period. Notably, reoptimization does not necessarily mean that the price is eventually changed.¹⁹ The present expected value of future profits generated when P_{it}^* is effective equals

$$\begin{aligned} & \left[P_{it}^* Y_{it|t} - \Psi_{it}(Y_{it|t}) \right] + \theta_i \beta_i E_t \left[P_{i,t+1}^* Y_{i,t+1|t} - \Psi_{i,t+1}(Y_{i,t+1|t}) \right] \\ & + \dots + \theta_i^\infty \beta_i^\infty E_t \left[P_{i,t+\infty}^* Y_{i,t+\infty|t} - \Psi_{i,t+\infty}(Y_{i,t+\infty|t}) \right], \end{aligned}$$

which can be rewritten as

$$\sum_{k=0}^{\infty} \theta_i^k \beta_i^k E_t \left[P_{it}^* Y_{i,t+k|t} - \Psi_{it}(Y_{i,t+k|t}) \right], \quad (1)$$

where $Y_{i,t+k|t}$ is firm i 's production in period $t+k$ when the price was lastly reset in period t . $\Psi_{it}(\cdot)$ denotes the cost function of firm i , and β_i is a firm or product-specific discount factor. The constraint that supply equals demand in period $t+k$ writes

$$Y_{i,t+k|t} = C_{i,t+k|t}, \quad (2)$$

where $C_{i,t+k|t}$ is demand for good i in period $t+k$ when the price was lastly reset in period t . Following Woodford (2003, p. 147) and Galí (2008, p. 42), the demand function for good i in period $t+k$ is given by

$$C_{i,t+k|t} = \left(\frac{P_{it}^*}{P_{t+k}} \right)^{-\epsilon_i} C_{t+k}, \quad (3)$$

where P_{t+k} denotes an aggregate price index over all competitor firms, C_{t+k} denotes an aggregate consumption index over all competing goods and ϵ_i is the price elasticity of

¹⁸Since each firm is just the producer of a single good, I can simplify notation by indexing a firm and the good that the firm produces with the same letter.

¹⁹In fact, survey evidence shows that firms reevaluate prices considerably more often than they actually change them (see Fabiani *et al.*, 2006).

demand of good i . Substituting Equation (3) into Equation (2) yields

$$Y_{i,t+k|t} = \left(\frac{P_{it}^*}{P_{t+k}} \right)^{-\epsilon_i} C_{t+k}. \quad (4)$$

Using Equations (1) and (4) the optimization problem of firm i takes the form

$$\max_{P_{it}^*} \sum_{k=0}^{\infty} \theta_i^k \beta_i^k E_t \left[P_{it}^* Y_{i,t+k|t} - \Psi_{it}(Y_{i,t+k|t}) \right]$$

subject to the sequence of demand constraints

$$Y_{i,t+k|t} = \left(\frac{P_{it}^*}{P_{t+k}} \right)^{-\epsilon_i} C_{t+k}$$

for $k = 0, \dots, \infty$. The first-order condition associated with this problem is

$$\sum_{k=0}^{\infty} \theta_i^k \beta_i^k E_t \left[(1 - \epsilon_i) \left(\frac{P_{it}^*}{P_{t+k}} \right)^{-\epsilon_i} C_{t+k} + \epsilon_i P_{it}^{*\epsilon_i - 1} \left(\frac{1}{P_{t+k}} \right)^{\epsilon_i} C_{t+k} \Psi'_{i,t+k}(Y_{i,t+k|t}) \right] = 0, \quad (5)$$

where $\Psi'_{i,t+k}(Y_{i,t+k|t})$ denotes firm i 's nominal marginal cost of production in period $t+k$ given that the firm last reset its price in period t . Solving Equation (5) for P_{it}^* and rearranging yields

$$P_{it}^* = \frac{\epsilon_i}{\epsilon_i - 1} \sum_{k=0}^{\infty} \theta_i^k \beta_i^k E_t \left[\Psi'_{i,t+k}(Y_{i,t+k|t}) \frac{Y_{i,t+k|t}}{Y_{i|t}} \right], \quad (6)$$

where $Y_{i|t} = \sum_{k=0}^{\infty} \theta_i^k \beta_i^k Y_{i,t+k|t}$, hence, $Y_{i,t+k|t}/Y_{i|t}$ is the share of production of period $t+k$ in the expected present value of total future production generated when P_{it}^* is effective.²⁰ The term $\epsilon_i/(\epsilon_i - 1)$ is decreasing in firm i 's price elasticity of demand, ϵ_i , and is commonly interpreted as a markup over marginal costs which reflects a firm's pricing power. Thus, according to Equation (6), the optimal price of firm i in period t equals a markup times the expected present value of total future marginal costs where the marginal cost in each period is weighted with the share of expected production in the expected present value of total future production. Equation (6) can be rewritten in form of the difference equation

$$P_{it}^* = \frac{\epsilon_i}{\epsilon_i - 1} \Psi'_{it}(Y_{it|t}) \frac{Y_{it|t}}{Y_{i|t}} + E_t \left[P_{i,t+1}^* \right]. \quad (7)$$

²⁰ $Y_{i|t}$ is an *expected* value because $Y_{i,t+k|t}$ realizes with probability θ_i^k .

Subtracting $P_{i,t-1}$ from both sides of Equation (7), expanding the right-hand side with $P_{it} - P_{it}$ and using the fact that $P_{it} - P_{i,t-1} = (1 - \theta)(P_{it}^* - P_{i,t-1})$ brings us to

$$P_{it} - P_{i,t-1} = \frac{1 - \theta_i}{\theta_i} \frac{\epsilon_i}{\epsilon_i - 1} \Psi'_{it}(Y_{it|t}) \frac{Y_{it|t}}{Y_{i|t}} + \frac{1}{\theta_i} E_t \left[P_{i,t+1} - P_{it} \right]. \quad (8)$$

What remains to be shown in order to derive a micro Phillips curve is how the marginal cost of production, $\Psi'_{it}(Y_{it|t})$, relates to the product-specific economic activity, here the product-specific capacity utilization rate.²¹ I assume that the production function for good i is given by

$$Y_{it|t} = N_{it}^{\alpha_i} K_{it}^{\gamma_i} \quad (9)$$

where N_{it} is labor input, K_{it} is capital input, $0 < \alpha_i < 1$, $0 < \gamma_i < 1$ and $\alpha_i + \gamma_i < 1$, hence, Equation (9) exhibits decreasing returns to scale.²² The cost of production is given by

$$\Psi_{it}(Y_{it|t}) = \frac{W_{it}}{P_t} N_{it}(Y_{it|t}) + Q_{it} K_{it}(Y_{it|t}) + R_{it} \bar{K}_i, \quad (10)$$

where W_{it}/P_t is the real wage, N_{it} is labor input, Q_{it} is the real cost of employing a unit of capital, K_{it} is capital input, R_{it} is the real interest rate and \bar{K}_i denotes capital capacity (i.e. if $K_{it} = \bar{K}_i$ then the capital capacity that is available for the production of good i is fully used). Derivating Equation (10) with respect to $Y_{it|t}$ yields

$$\Psi'_{it}(Y_{it|t}) = \frac{W_{it}}{P_t} N'_{it}(Y_{it|t}) + Q_{it} K'_{it}(Y_{it|t}), \quad (11)$$

where the first term on the right side of Equation (11) denotes the real marginal cost of labor, whereas the second term represents the real marginal cost of capital. Using Equation (9), Equation (11) can be expressed as

$$\Psi'_{it}(Y_{it|t}) = \frac{2}{\alpha_i} \left(\frac{\alpha_i}{\gamma_i} \right)^{1-\alpha_i} \left(\frac{W_{it}}{P_t} \right)^{\alpha_i} \left(Q_{it} \right)^{1-\alpha_i} \left(\bar{K}_i \right)^{1-\alpha_i-\gamma_i} \left(\frac{K_{it}}{\bar{K}_i} \right)^{1-\alpha_i-\gamma_i}. \quad (12)$$

²¹Woodford (2003) and Galí (2008) derive a relationship between aggregate inflation and marginal cost minus a value of marginal cost that would be chosen if $\theta_i = 0$ (= absence of nominal rigidity). Further, they relate the marginal cost terms to the difference between aggregate output and the level of aggregate output that would prevail in absence of nominal rigidity. They call the latter term natural output, and they refer to the difference between aggregate output and natural output as the output gap. While being intriguing from a theoretical perspective, natural output as defined by Woodford and Galí is a counterfactual variable that cannot be observed empirically. In contrast, I derive a theoretically sensible relationship between marginal cost of production and the capacity utilization rate, where the latter variable can actually be observed and is widely recognized as a sensitive measure of the business cycle that performs considerably well as a predictor of GDP growth and as a predictor of inflation in Phillips curve specifications (see, e.g., Stock and Watson, 1999a,b). See Graff and Sturm (2010) for a thorough discussion of the theoretical concept and empirical measurement of the output gap.

²²The assumption of decreasing returns to scale follows Galí (2008).

Finally, plugging Equation (12) into Equation (8) yields

$$P_{it} - P_{i,t-1} = \frac{1 - \theta_i}{\theta_i} \frac{\epsilon_i}{\epsilon_i - 1} \Sigma_{it|t} \left(\frac{W_{it}}{P_t} \right)^{\alpha_i} Q_{it}^{1-\alpha_i} \bar{K}_i^{1-\alpha_i-\gamma_i} \tilde{K}_{it}^{1-\alpha_i-\gamma_i} + \frac{1}{\theta_i} E_t \left[P_{i,t+1} - P_{it} \right], \quad (13)$$

where

$$\Sigma_{it|t} = \frac{2}{\alpha_i} \left(\frac{\alpha_i}{\gamma_i} \right)^{1-\alpha_i} \frac{Y_{it|t}}{Y_{it}}.$$

and $\tilde{K}_{it} \equiv K_{it}/\bar{K}_i$ can be interpreted as the product-specific capacity utilization rate. Since $\alpha_i + \gamma_i < 1$, Equation (13) implies that $P_{it} - P_{i,t-1}$ is increasing in \tilde{K}_{it} . This is plausible from an intuitive standpoint and is supported by empirical research (see Lein, 2010). Also, it seems plausible that employees claim higher real wages, W_{it}/P_t , and the real cost of employing a unit of capital, Q_{it} , is the higher, the closer is the firm working to full capacity, i.e. the higher is the capacity utilization rate, \tilde{K}_{it} . Furthermore, there is ample empirical evidence that firms which face stronger price competition or a higher price elasticity of demand, ϵ_i , reevaluate or reoptimize their prices with higher frequency, $(1 - \theta_i)$, though without necessarily changing them more often (see Fabiani *et al.*, 2006, p. 14). This allows us to rewrite Equation (13) more compactly as

$$P_{it} - P_{i,t-1} = \phi(\epsilon_i) \mu(\epsilon_i) \bar{K}_i^{1-\alpha_i-\gamma_i} H_{it}(\tilde{K}_{it}) + \kappa(\epsilon_i) E_t \left[P_{i,t+1} - P_{it} \right], \quad (14)$$

where the function

$$H_{it}(\tilde{K}_{it}) = \left(\frac{W_{it}}{P_t} \right)^{\alpha_i} Q_{it}^{1-\alpha_i} \tilde{K}_{it}^{1-\alpha_i-\gamma_i}$$

is increasing in the capacity utilization rate, \tilde{K}_{it} , where the functions

$$\phi(\epsilon_i) = \frac{1 - \theta_i(\epsilon_i)}{\theta_i(\epsilon_i)} \Sigma_{it|t}$$

and

$$\kappa(\epsilon_i) = \frac{1}{\theta_i(\epsilon_i)}$$

are increasing in the degree of price competition or price elasticity of demand, ϵ_i , and where the function

$$\mu(\epsilon_i) = \frac{\epsilon_i}{\epsilon_i - 1}$$

is decreasing in ϵ_i .²³ Equation (14) reveals that there are two opposing effects of the degree of price competition on the slope of the micro Phillips curve. On the one hand, the higher is the degree of price competition, the higher will be the frequency of price revaluations implying a higher slope of the micro Phillips curve.²⁴ On the other hand,

²³The intermediate steps of the derivations in this section are available on request.

²⁴See also Rogoff (2006).

the higher is the degree of price competition, the lower will be the markup over marginal costs resulting in a lower slope of the micro Phillips curve. In other words, the higher the degree of price competition, the less pricing power firms have and the less they can transmit changes in capacity utilization into price changes implying a lower slope of the micro Phillips curve. A priori, it is not clear which of the two effects dominates. I am not able to discriminate between the two effects in my empirical analysis, I can only analyze whether one outweighs the other. As turns out in Section 5, the latter effect clearly dominates: I find that the slope of the micro Phillips curve is strongly decreasing in the degree of price competition. Moreover, as can be seen from Equation (14), the derivative of the actual price change with respect to the expected future price change is increasing in the degree of price competition. This makes intuitively sense as firms facing stronger competition will probably act more forward-looking.

4 Data and econometric model

The empirical analysis in this study bases on a panel of Swiss manufacturing products. Contrary to the assumption in Section 3, there is not a continuum of products i , but the total number of products equals 264. The data are on a quarterly basis and are available for the years 1990, 1993, 1996, 2002, 2005 and 2008. Hence, in my analysis the length of a period t equals one quarter. None of the products operates in the same market, thus, each product faces its individual degree of price competition, ϵ_{it} .²⁵ The data are collected by the KOF Swiss Economic Institute (KOF) in its Industry Business Tendency and Innovation Surveys.²⁶ The KOF surveys a set of manufacturing firms on the respective principal good they produce. The set of variables used in this study includes first, a qualitative proxy for the product-specific sales transaction price *inflation*,

$$\pi_{it} = \begin{cases} 1 & \text{if firm } i \text{ indicates that the actual sales transaction price of its main product } i \\ & \text{increased in the current period } t \text{ as compared to the preceding period } t - 1, \\ 0 & \text{if firm } i \text{ indicates that the actual sales transaction price of its main product } i \\ & \text{remained unchanged in period } t \text{ as compared to period } t - 1, \\ -1 & \text{if firm } i \text{ indicates that the actual sales transaction price of its main product } i \\ & \text{decreased in period } t \text{ as compared to period } t - 1, \end{cases}$$

²⁵In the theory section, ϵ_i does not vary over time. In contrast, the empirical information at hand allows for time-varying ϵ_i . De facto, however, ϵ_i hardly varies over time.

²⁶See <http://kof.ethz.ch/en/surveys>. In fact, the first three variables described below are collected every quarter since 1984, whereas the latter two are collected since 1990 every three years only. This results in a quarterly sample with gaps of two years.

second, a qualitative proxy for the product-specific sales transaction price *inflation expectation*,

$$E_{it}[\pi_{i,t+1}] = \begin{cases} 1 & \text{if firm } i \text{ indicates that it expects the actual sales transaction price of its} \\ & \text{main product } i \text{ to increase in period } t + 1 \text{ as compared to period } t, \\ 0 & \text{if firm } i \text{ indicates that it expects the actual sales transaction price of its} \\ & \text{main product } i \text{ to remain unchanged in period } t + 1 \text{ as compared to } t, \\ -1 & \text{if firm } i \text{ indicates that it expects the actual sales transaction price of its} \\ & \text{main product } i \text{ to decrease in period } t + 1 \text{ as compared to period } t, \end{cases}$$

and third, the product-specific *capacity utilization* rate, \tilde{y}_{it} , in 5%-categories from 50% to 100%. The literature widely recognizes capacity utilization as a sensitive measure of the business cycle that performs considerably well as a predictor of GDP growth and as a predictor of inflation in Phillips curve specifications (see, e.g., Stock and Watson, 1999a,b). Fourth, I use a qualitative indicator for the *change in* product-specific production *capacity*,

$$\Delta \bar{K}_{it} = \begin{cases} 1 & \text{if firm } i \text{ indicates that the production capacity for its main product } i \\ & \text{increased in period } t \text{ as compared to period } t - 1, \\ 0 & \text{if firm } i \text{ indicates that the production capacity for its main product } i \\ & \text{remained unchanged in period } t \text{ as compared to period } t - 1, \\ -1 & \text{if firm } i \text{ indicates that the production capacity for its main product } i \\ & \text{decreased in period } t \text{ as compared to period } t - 1 \end{cases}$$

The theoretically derived micro Phillips curve in Equation (14) incorporates capital capacity, K_i . For the empirical analysis, only $\Delta \bar{K}_{it}$ is available. Fifth, I employ firms i 's appraisal of the *degree of price competition* in the key sales market of product i during period t in (ordinal) rating scale form,

$$\epsilon_{it} = \begin{cases} 1 & \text{if very weak,} \\ 2 & \text{if medium weak,} \\ 3 & \text{if medium strong,} \\ 4 & \text{if very strong.} \end{cases}$$

The variable ϵ_{it} may be criticized as being just a subjective measure of the actual degree of price competition. However, the variable has several striking advantages. First, the variable is product- and market-specific, i.e. each firm is asked to indicate the degree of price competition in the key sales market for exactly the product for which the firm also indicates inflation, inflation expectations and capacity utilization. In contrast, usual proxies for the degree of competition are sector-specific or firm-specific at best. This evokes great imprecisions and may explain the often weak results in the literature (see Section 2),

because the degree of competition can vary greatly even across similar products, across the goods produced in one firm and across the very same good sold in different markets. For instance, it is not uncommon that firms differentiate production into two or more similar goods, some of them being of lower quality and being sold at a lower price and higher quantities in more competitive markets, whereas others being of higher quality and being sold at a higher price and lower quantities in less competitive markets. Second, firms are explicitly asked for the degree of *price* competition as to proxy the product’s price elasticity of demand. Thus, the empirical competition measure directly relates to the theoretical competition measure in Section 3.²⁷ Third, each firm reports about the principal good it produces and about the good’s key sales market, hence, it will probably be well informed about the characteristics of that good and market.²⁸ Anyway, as an alternative – more objective – competition measure, I use firms’ gross profit rates, i.e. the ratio between profits and total costs. This variable is only firm-specific – and not product-specific as is the degree of price competition, ϵ_{it} . Still, the variable is well accepted in the literature as a proxy for the degree of competition, that a firm faces.²⁹ A higher profit rate indicates a lower degree of competition. Following Boivin *et al.* (2009), I use each firm i ’s annual gross *profit rate* averaged over the years in the sample, Π_i . This way, I alleviate business cycle-driven profit fluctuations which do not alter the general degree of competition among firms. The cost of having no time-varying competition measure is negligible, since the degree of competition does not seem to vary a lot over time (at least when being classified in broad categories). Notably, both competition measures – ϵ_{it} and Π_i – deliver the same empirical results. The forementioned variables on inflation expectation, capacity utilization, degree of price competition and profit rate provide product- or firm-specific information and, thus, can be classified as microeconomic state variables. It is important to separate the effect of these variables from macroeconomic influences – such as aggregate shocks, aggregate inflation or any of other seasonal-, year- or period-specific effects – which are likely to affect product-specific inflation as well. I control for these macroeconomic state variables altogether by employing a full set of period dummy variables summarized in the vector γ_t . Period dummy variables also account for the well established fact that firms reset prices more often in the fourth quarter than in other quarters. In addition, I employ one-period to eight-period Taylor dummy variables to account for the possibility that firms resort to time-dependent pricing rules.

²⁷Hoeberichts and Stokman (2010) report for a firm survey on price setting behavior in the Netherlands that the self-reported degree of competition is strongly correlated with the importance attached by firms to changes in competitors’ prices.

²⁸One might argue that the subjective nature of the variable makes it not suitable for cross-firm comparisons. If this would be the case, then a lot of variables in social science, namely those which involve self-assessment, will be not useful for general analysis. Further, one might argue that firms generally tend to make appear business conditions being more difficult than they actually are, leading them to overstate the degree of price competition. However, I see no reason why firms should provide biased information in a fully anonymous survey.

²⁹See, e.g., Boivin *et al.* (2009) and Bils and Klenow (2004) who call the profit rate “markup”.

Following Taylor (1980), a firm resets its price at fixed time intervals. Accordingly, a n -period Taylor dummy variable takes value one for product i if the price of product i was last reset n periods ago; otherwise the variable is zero. The choice of one to eight periods is rather arbitrary; nonetheless my results are not affected by the choice of the Taylor dummy variable structure. The Taylor dummy variables are summarized in the vector $\boldsymbol{\mu}_{it}$.³⁰

Table 1 shows the survey questions and response categories attached to the variables used. Table 2 presents summary statistics for each variable. The first row of Table 2 shows that in about 73% of all cases prices are left unchanged, hence, the quarterly frequency of price changes is about 27%. Further, there are substantially more price decreases than increases. This asymmetry holds especially for products facing relatively high competition (see Table 3) and is probably due to the relatively large number of discounts granted when firms face high competition.³¹ The inflation expectations variable shows a similar pattern as can be seen from the second row of Table 2. Figure 1 displays the average degree of price competition over time. After having increased during the first half of the 1990s the degree of price competition displays a slight downward trend from the second half of the 1990s onwards. However, the differences over time are far from being significant at conventional levels. The high average degree of price competition corresponds to the traditionally high degree of openness of the Swiss economy and the traditionally low level of regulation in the Swiss manufacturing sector. In fact, only 22% of the products in the sample are not sold on foreign markets. The upward shift during the mid-1990s may be caused by an increase in market competition in the European Union, the main sales market of Swiss products, due to the deepening of the single European market on the grounds of the Maastricht Treaty in 1992 and due to substantial market deregulation efforts thereafter. The slight downward trend from the second half of the 1990s onwards may reflect the fact that Swiss manufacturing firms increasingly resort to niche production as a response to increased globalization, internationally high labor costs and persistent appreciation of the Swiss franc. Table 3 displays summary statistics for the different degrees of price competition. As can be seen from row 1, my panel is unbalanced in the sense that the higher degrees of price competition include substantially more observations than the lower degrees. Nevertheless, in each category the number of observations is sufficiently high to yield meaningful results. Row 4 ($\pi_{it} = 0$) reveals that the share of no change in price decreases with the degree of price competition, hence, the frequency of price changes in-

³⁰See Klenow and Kryvtsov (2008) and Lein (2010) for interesting studies on the effect of microeconomic versus macroeconomic state variables on price-setting.

³¹As stated in Table 1, firms are explicitly asked to indicate the prices they actually (expect to) charge including discounts. In contrast, PPI statistics base on list prices which do not include discounts and where price increases are slightly more frequent than price decreases (see Vermeulen *et al.*, 2007, amongst others).

creases with the degree of price competition. This finding is in line with the results by Bils and Klenow (2004), Álvarez and Hernando (2007) and others cited in the literature review in Section 2. Nonetheless, as will be shown in the next section, the higher is the degree of price competition, the less frequently prices respond to changes in capacity utilization. Further, rows 3 and 5 reveal a clear asymmetry between the frequency of price increases and the frequency of price reductions. The frequency of price increases is rather stable over the different degrees of price competition, whereas the frequency of price reductions increases in the degree of price competition. This suggests that firms facing stronger competition feel more obliged to grant discounts and other price reductions in order to extend or keep their market share. In contrast, as regards price increases, firms facing stronger competition follow about the same pattern than firms facing weaker competition.

After data description and summary statistics, I now turn to the econometric model used in the empirical analysis. In the context of this study, product-specific sales transaction price inflation, π_{it}^* , can be considered as a latent continuous random variable that determines the observed outcome, π_{it} , by the following rule:

$$\begin{aligned}\pi_{it} &= -1 && \text{if and only if } -\infty < \pi_{it}^* < 0, \\ \pi_{it} &= 0 && \text{if and only if } \pi_{it}^* = 0, \\ \pi_{it} &= +1 && \text{if and only if } 0 < \pi_{it}^* < \infty.\end{aligned}$$

Thus, the econometric model takes the form

$$P(\pi_{it} = j) | \mathbf{x}_{it}, \boldsymbol{\beta} = \begin{cases} F(0 - \mathbf{x}'_{it} \boldsymbol{\beta}) - F(-\infty - \mathbf{x}'_{it} \boldsymbol{\beta}) & \text{if } j = -1, \\ F(0 - \mathbf{x}'_{it} \boldsymbol{\beta}) & \text{if } j = 0, \\ F(\infty - \mathbf{x}'_{it} \boldsymbol{\beta}) - F(0 - \mathbf{x}'_{it} \boldsymbol{\beta}) & \text{if } j = +1. \end{cases} \quad (15)$$

where $F(\cdot)$ is a logistic distribution function, thus,

$$F(\alpha - \mathbf{x}'_{it} \boldsymbol{\beta}) = \Lambda(\alpha - \mathbf{x}'_{it} \boldsymbol{\beta}) \equiv \frac{e^{\alpha - \mathbf{x}'_{it} \boldsymbol{\beta}}}{1 + e^{\alpha - \mathbf{x}'_{it} \boldsymbol{\beta}}},$$

where $\alpha = -\infty, 0, \infty$. According to the theoretical relationship derived in Equation (14), the slope of the Phillips curve, namely the derivative of inflation with respect to capacity utilization, depends on the degree of price competition. As discussed in Section 3, there are two opposing effects of the degree of price competition on the slope of the Phillips curve, and it is a priori not clear if, and if yes, which of the two effects outweighs the other. In order to test whether the slope of the Phillips curve does indeed increase or decrease in the degree of price competition, I employ the forementioned ordered logit model including interactions between capacity utilization and the different degrees of

price competition such that the statistical relationship between capacity utilization and inflation can potentially depend on the degree of price competition. Consequently, vector \mathbf{x}_{it} writes

$$\mathbf{x}'_{it} = \left[E_{it}[\pi_{i,t+1}] \quad \Delta \bar{K}_{it} \quad \tilde{K}_{it} \quad \epsilon_2 \quad \epsilon_3 \quad \epsilon_4 \quad \epsilon_2 \cdot \tilde{K}_{it} \quad \epsilon_3 \cdot \tilde{K}_{it} \quad \epsilon_4 \cdot \tilde{K}_{it} \quad \boldsymbol{\gamma}'_t \quad \boldsymbol{\mu}'_{it} \right].$$

where ϵ_n equals one if $\epsilon_{it} = n$ and equals zero otherwise for $n = 1, 2, 3, 4$. ϵ_1 and $\epsilon_1 \cdot \tilde{K}_{it}$ are the reference categories and, thus, do not figure in \mathbf{x}'_{it} .³² When the profit rate variable, Π_i , is employed as an alternative proxy for the degree of price competition, the vector \mathbf{x}_{it} writes

$$\mathbf{x}'_{it} = \left[E_{it}[\pi_{i,t+1}] \quad \Delta \bar{K}_{it} \quad \tilde{K}_{it} \quad \Pi_i \quad \Pi_i \cdot \tilde{y}_{it} \quad \boldsymbol{\gamma}'_t \quad \boldsymbol{\mu}'_{it} \right].$$

On the basis of the ordered logit interaction effects model, I estimate the effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on $P(\pi_{it} = 1)$ or $P(\pi_{it} = -1)$, respectively, conditional on the different values of ϵ_{it} . In case $j = 1$, this marginal effect amounts to

$$\left. \frac{\partial P(\pi_{it} = 1)}{\partial \tilde{K}_{it}} \right|_{\epsilon_n=1} = (\beta_{\tilde{K}_{it}} + \beta_{\tilde{K}_{it}\epsilon_n}) \left[\frac{e^{\infty - \mathbf{x}'_{it}\boldsymbol{\beta}}}{(1 + e^{\infty - \mathbf{x}'_{it}\boldsymbol{\beta}})^2} - \frac{e^{0 - \mathbf{x}'_{it}\boldsymbol{\beta}}}{(1 + e^{0 - \mathbf{x}'_{it}\boldsymbol{\beta}})^2} \right] \quad (16)$$

where $n = 1, 2, 3, 4$ and where $\beta_{\tilde{K}_{it}}$ is the coefficient attached to \tilde{K}_{it} and $\beta_{\tilde{K}_{it}\epsilon_n}$ is the coefficient attached to the interaction effect $\tilde{K}_{it} \cdot \epsilon_n$.³³ When the profits variable is employed as an alternative competition measure, the effect of a marginal increase in \tilde{K}_{it} on $P(\pi_{it} = 1)$, conditional on the value $\bar{\Pi}_i$, becomes

$$\left. \frac{\partial P(\pi_{it} = 1)}{\partial \tilde{K}_{it}} \right|_{\Pi_i=\bar{\Pi}_i} = (\beta_{\tilde{K}_{it}} + \beta_{\tilde{K}_{it}\bar{\Pi}_i} \bar{\Pi}_i) \left[\frac{e^{\infty - \mathbf{x}'_{it}\boldsymbol{\beta}}}{(1 + e^{\infty - \mathbf{x}'_{it}\boldsymbol{\beta}})^2} - \frac{e^{0 - \mathbf{x}'_{it}\boldsymbol{\beta}}}{(1 + e^{0 - \mathbf{x}'_{it}\boldsymbol{\beta}})^2} \right], \quad (17)$$

where is the coefficient attached to \tilde{K}_{it} and $\beta_{\tilde{K}_{it}\bar{\Pi}_i}$ is the coefficient attached to the interaction effect $\tilde{K}_{it} \cdot \bar{\Pi}_i$. Analogous equations to (16) and (17) can be written for $j = -1$. In principle, the marginal effect can be evaluated for any arbitrary value $\bar{\Pi}_i$. It makes sense that $\bar{\Pi}_i$ lies between the lowest and the highest sample value of Π_i . In the empirical analysis, I evaluate the marginal effect at the 10th, 40th, 60th and 90th percentile of the sample distribution of Π_i , where the first (very low profit) value proxies a very strong degree of competition, the second (medium low profit) value proxies a medium strong degree of competition, the third (medium high profit) value proxies a medium weak degree

³²All other variables have been defined above. As noted before, ϵ_{it} is in rating scale form, hence, it is an ordinal variable. This is why one cannot simply employ the variables ϵ_{it} and $\epsilon_{it} \cdot \tilde{K}_{it}$, but ϵ_{it} must be transformed in dummy variable form.

³³Less precisely, yet more compactly, the right hand side of Equation (16) may be rewritten in the form $(\beta_{\tilde{K}_{it}} + \beta_{\tilde{K}_{it}\epsilon_n})F(\cdot)[1 - F(\cdot)]$.

of competition, and the fourth (very high profit) value proxies a very weak degree of competition. Admittedly, the choice of the percentiles involves some arbitrariness, however, the results are robust to choosing different percentiles. From Equations (16) and (17) it becomes clear that the marginal effect of \tilde{K}_{it} depends not only on the value of ϵ_{it} or $\bar{\Pi}_i$, respectively, but also on the values of the other covariates in \mathbf{x}_{it} . Unless stated otherwise, I will always estimate the marginal effect at the mean of the covariates.³⁴

5 Results

Equation (15) is estimated using heteroscedasticity robust standard errors following Huber (1967) and White (1980, 1982). Results are summarized in Table 4. As one would expect, inflation expectation, $E[\pi_{i,t+1}]$, and capacity utilization, \tilde{y}_{it} , are both significantly positive. In contrast, the capacity change variable, $\Delta\bar{K}_{it}$, turns out to be insignificant at conventional levels. Further, the Taylor dummies prove jointly significant at conventional levels (not shown in Table 4). The same applies to the period dummies. As discussed in the last section, I refrain from interpretation of the interaction terms in Table 4. Rather, I focus on Equation (16), namely on the effect of a marginal increase in \tilde{K}_{it} on $P(\pi_{it} = j)$, conditional on the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$.

Table 5 shows the estimated effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on the probability of a price increase, $P(\pi_{it} = 1)$, for the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$, evaluated at the sample mean of capacity utilization, $\tilde{K}_{it} = 81.92$, and at the sample means of the other covariates. It turns out that the marginal effect is decreasing substantially with the degree of price competition. The marginal effect for products that face a very weak degree of price competition, $\epsilon_{it} = 1$, is about one and a half times bigger than the marginal effect for products that face a medium weak degree of price competition, $\epsilon_{it} = 2$ (0.199% compared to 0.133%). In contrast, there is only a slight difference between the marginal effect for products that face a medium weak degree of price competition compared to products facing a medium strong degree of price competition, $\epsilon_{it} = 3$ (0.133% compared to 0.110%). Further, the marginal effect for products facing a medium strong degree of price competition is more than three times bigger than the marginal effect for products facing a very strong degree of price competition, $\epsilon_{it} = 4$ (0.110% compared to 0.029%). Comparing the marginal effect for $\epsilon_{it} = 1$ to the one for $\epsilon_{it} = 4$, the former is 6.86 times higher than the latter, or the latter is 85.42% lower compared to the former. The marginal effects for $\epsilon_{it} = 1, 2, 3$ are significantly different from zero at the five percent level at least, and the marginal effect for $\epsilon_{it} = 4$ is clearly

³⁴Ai and Norton (2003) highlight that in qualitative response models we cannot infer the interaction effect of two variables just from the coefficient of the interaction term of the variables. In contrast to Ai and Norton, I am neither interested in the interaction terms nor in the interaction effect as such, but in the effect of a marginal increase in \tilde{K}_{it} on $P(\pi_{it} = j)$, conditional on different degrees of competition.

not significantly different from zero at conventional levels. As can be seen from Table 6, the marginal effect for $\epsilon_{it} = 1$ is not significantly different from the marginal effects for $\epsilon_{it} = 2, 3$ at conventional levels. This might be due to the relatively low number of observations for $\epsilon_{it} = 1$. At least, the marginal effect for $\epsilon_{it} = 1$ is significantly different from the marginal effect for $\epsilon_{it} = 4$ at the ten percent level. Further, the marginal effect for $\epsilon_{it} = 2$ is not significantly different from the marginal effect for $\epsilon_{it} = 3$ at conventional levels, which reflects the fact that the values are quite close to each other. The marginal effects for $\epsilon_{it} = 2, 3$ are significantly different from the marginal effect for $\epsilon_{it} = 4$ at the ten percent level.

Figure 2 displays the estimated effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on the probability of a price increase, $P(\pi_{it} = 1)$, for the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$. In contrast to Table 5, the marginal effect is not only evaluated at the sample mean, but over the full range of capacity utilization. As before, the evaluation for each level of capacity utilization occurs at the sample means of the other covariates. Figure 2 confirms the finding of Table 5 for the full range of capacity utilization: prices of products, that face a weaker degree of price competition, are more likely to increase in response to increases in capacity utilization, as compared to prices of products, that face a stronger degree of price competition. An exception being capacity utilization rates of 50% to 60%, where the marginal effect for products facing a medium weak degree of price competition, $\epsilon_{it} = 2$, and products facing a medium strong degree of price competition, $\epsilon_{it} = 3$, is fairly equal. Further, the marginal effect for products, that face a very weak degree of price competition, $\epsilon_{it} = 1$, is increasing in capacity utilization. In fact, the marginal effect at full capacity usage is more than three times as high as the marginal effect at half capacity usage. The same pattern occurs for products facing a medium weak degree of price competition and – less pronounced – for products facing a medium strong degree of price competition. In contrast, the marginal effect for products, that face a very strong degree of price competition, $\epsilon_{it} = 4$, is rather stable over the range of capacity utilization. In sum, whereas firms facing weaker competition are *more likely* to increase prices in response to changes in capacity utilization *when the actual level of capacity utilization is higher*, the likelihood of a price increase for products facing very strong competition does not depend on the level of capacity utilization.

Table 7 focuses on the probability of a price increase, $P(\pi_{it} = 1)$, rather than on marginal effects. Both for average capacity usage, $\tilde{K}_{it} = 81.92$, as well as for full capacity usage, $\tilde{K}_{it} = 100$, the probability of a price increase is decreasing in the degree of price competition – an exception being $\epsilon_{it} = 2$ and $\epsilon_{it} = 3$ for $\tilde{K}_{it} = 81.92$ (see columns 1 and 2 of Table 7). However, the price increase probability for products facing very weak competition, $\epsilon_{it} = 1$, is not significantly different at conventional levels from the price

increase probabilities for products facing medium weak or medium strong competition, $\epsilon_{it} = 2$ and $\epsilon_{it} = 3$ (see columns 1 and 4 of Table 8). At least, the former is significantly different at the five percent level from the price increase probability for products facing very strong competition, $\epsilon_{it} = 4$ (see *ibid.*). Also, whereas the price increase probabilities for products facing medium weak and medium strong competition are far from being significantly different from each other at conventional levels, both probabilities are significantly different at conventional levels from the price increase probability for products facing very strong competition (see last row of Table 8). As can be seen from column 3 of Table 7, the change in the probability of a price increase as capacity moves from average to full usage is also decreasing in the degree of price competition. Admittedly, under very weak competition, this change is not significantly different at conventional levels from the changes under higher competition (see column 1 of Table 9). This might again be due to a small number of observations for products facing very weak competition. Also, the changes under medium weak and medium strong competition are not significantly different from each other at conventional levels (see column 2 of Table 9). At least, the changes under medium weak and medium strong competition are significantly different at conventional levels from the change under very strong competition. In sum, the results on price increase probabilities coincide with the aforementioned results on marginal effects.

Overall, the results of Figure 2 and Tables 5 to 9 render support for the theory as put forward in Section 3. The slope of the micro Phillips curve, i.e. the product-specific relation between inflation and economic activity, varies greatly with the degree of price competition a product faces: the higher is the degree of price competition, the weaker will be the link between inflation and economic activity; for products, that face a very high degree of price competition, the link between inflation and economic activity breaks down completely. Moreover, the micro Phillips curve is non-linear.³⁵ These insights have important policy implications as will be highlighted in Section 7.

Having focused on price increases so far, I now repeat the analysis for prices decreases. Table 10 shows the estimated effect of a marginal decrease in capacity utilization, \tilde{K}_{it} , on the probability of a price decrease, $P(\pi_{it} = -1)$, for the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$ evaluated at the sample mean of capacity utilization, $\tilde{K}_{it} = 81.92$, and at the sample means of the other covariates. The marginal effect is increasing from 0.00230 for products facing very weak competition, $\epsilon_{it} = 1$, to 0.00336 for products facing medium weak competition, $\epsilon_{it} = 2$, then decreasing to 0.00245 for products facing medium strong competition, $\epsilon_{it} = 3$, and decreasing again to 0.00120 for products facing

³⁵See Gordon (1997), Filardo (1998), Clark *et al.* (2001) and Köberl and Lein (2009) on non-linearity of the Phillips curve. Or more exactly, its slope is increasing with the level of economic activity, but only for products which do not face very strong competition. In contrast, for products facing very strong competition, the slope of the micro Phillips curve does not depend on the level of economic activity.

very strong competition, $\epsilon_{it} = 4$. The first increase is clearly at odds with the theory from Section 3. At least, the decreases thereafter are in line with the theory. Also, corresponding to the results for price increases, products facing very strong competition are least likely to decrease prices in response to a decrease in capacity utilization. However, as can be seen from Table 11, the marginal effects are never significantly different from each other at conventional levels. In sum, whereas we previously found a clear link between higher competition and higher upward rigidity of prices, the results concerning downward rigidity are overall weaker: with exception of very low competition, higher competition tends to be associated with higher downward rigidity, which is in line with the theory from Section 3; however, the insignificance of differences between the marginal effects leads me to conclude that a link between higher competition and higher downward rigidity of prices can actually not be established. One might argue that higher competition ought to be associated with *lower* downward rigidity, i.e. the higher is the competition, that a product faces, the *higher* ought to be the effect of a marginal decrease in capacity utilization on the probability of a price decrease. Although this argument might seem intuitive, it contradicts both the theory and the empirical results.

Figure 3 displays the estimated effect of a marginal decrease in capacity utilization, \tilde{K}_{it} , on the probability of a price decrease, $P(\pi_{it} = -1)$, for the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$ over the full range of capacity utilization. As before, the evaluation for each level of capacity utilization occurs at the sample means of the other covariates. The marginal effects for products facing medium weak, medium strong and very strong competition, $\epsilon_{it} = 2, 3, 4$, behave in line with the theory: the weaker is the competition, the more likely it is that prices decrease in response to a marginal decrease in capacity utilization. However, the marginal effect for products facing very weak competition, $\epsilon_{it} = 1$, behaves somewhat queer: it is higher than the marginal effect for products facing medium weak competition throughout the full range of capacity utilization, and it crosses the marginal effect for products facing medium strong competition at a capacity utilization rate of 80%.

Table 12 focuses on the probability of a price decrease, $P(\pi_{it} = -1)$, rather than on marginal effects. The pattern for average capacity usage, $\tilde{K}_{it} = 81.92$, is queer: the price decrease probability first increases, then decreases, then increases again in the degree of price competition, ϵ_{it} (see column 1 of Table 12). Also, columns 1 to 3 of Table 13 reveal, that the probabilities for different degrees of price competition are significantly different from each other at conventional levels – with exception of the probability for $\epsilon_{it} = 2$ compared to the probability for $\epsilon_{it} = 3$. The pattern for half capacity usage, $\tilde{K}_{it} = 50$, corresponds to the pattern for marginal effects: the price decrease probability first increases and then decreases in competition (see column 2 of Table 12). However, as can be seen from Table 13, columns 4 to 6, the probabilities for different degrees of

price competition are generally far from being significantly different from each other at conventional levels. Table 12, column 3 reveals that the pattern for marginal effects holds also for the change in the price decrease probability as capacity decreases from average to half usage. But again, there do not exist any significant differences at conventional levels (see Table 14).

In sum, the results of Figure 3 and Tables 10 to 14 suggest that the theory from Section 3 must be rejected as regards price decreases. Either, there is no (clear) relation between the probability of a price decrease and the degree of price competition, or the pattern is more complicated than suggested by the theory. This negative result is in contrast to the aforementioned positive result on price increases.³⁶

6 Robustness

In a first step, I repeat the analysis of the last section including industry dummy variables. On the one hand, industry dummies control for idiosyncratic industry effects that might bias the results. On the other hand, industry dummies are a bad control because they might absorb inter-industry differences in the degree of competition. Anyhow, the results for price increases are virtually unchanged, and the results for price decreases become slightly stronger. For instance, in Table 11 the marginal effect for $\epsilon_{it} = 4$ now is significantly different from the marginal effect for $\epsilon_{it} = 2$ at the ten percent level. Also, the former is now not far from being significantly different from the marginal effects for $\epsilon_{it} = 1, 3$ at conventional levels (p values of 0.102 or 0.149). However, the results do not become sufficiently stronger such as to alter the conclusions from the last section.

As a second robustness test, I repeat the analysis using a firm's *profit rate*, Π_i , as an alternative proxy for the degree of competition that the firm faces. As discussed in Section 4, this proxy might be considered to be more objective and is well established in the literature. As in Section 5, I estimate Equation (15) using heteroscedasticity robust standard errors following Huber (1967) and White (1980, 1982). Results can be seen in Table 15. As one would expect, and in line with the result from Section 5, inflation expectation, $E[\pi_{i,t+1}]$, and capacity utilization, \tilde{y}_{it} , are both positive. However, only the former variable turns out significant at conventional levels. Further, as in the last section, the

³⁶Somewhat ironically, the negative result for price decreases might stem from the fact that I am using transaction prices instead of list prices (see Section 4). The literature prefers transaction to list prices, because the former are actually realized. However, the fact that transaction prices include discounts might distort the results, since discounts might not specifically be granted in response to decreases in capacity usage but might rather be determined by individual customer relations (discount in order to acquire a new customer, in order to keep a customer who intends to change to a competitor, in order to compensate for variation in the quality of a product etc.).

capacity change variable, $\Delta\bar{K}_{it}$, is insignificant at conventional levels, and Taylor dummies as well as period dummies prove jointly significant at conventional levels (not shown in Table 15). As discussed in section 4, I refrain from interpretation of the interaction terms in Table 15. Rather, I focus on Equation (17), namely on the effect of a marginal increase in \tilde{K}_{it} on $P(\pi_{it} = j)$, conditional on the profit rate level, Π_i .

Table 16 shows the estimated effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on the probability of a price increase, $P(\pi_{it} = 1)$, at the 10th, 40th, 60th and 90th percentile of the sample distribution over the profit rate variable, Π_i . The first (very low profit rate) value proxies a very strong degree of competition, the second (medium low profit rate) value proxies a medium strong degree of competition, the third (medium high profit rate) value proxies a medium weak degree of competition, and the fourth (very high profit rate) value proxies a very weak degree of competition. Admittedly, the choice of the percentiles involves some arbitrariness, however, my results are fully robust with respect to choosing different percentiles. As before, the marginal effects are always evaluated at the sample mean of capacity utilization, $\tilde{K}_{it} = 81.92$, and at the sample means of the other covariates. It turns out that the marginal effect increases steadily with the profit rate. For instance, the marginal effect at the 90th percentile of the profit rate distribution is 2.67 times bigger than the marginal effect at the 10th percentile, or the latter is 62.5% lower compared to the former. Also, Table 17 reveals that the marginal effects for the different percentiles are significantly different from each other at the 5 percent level. Since higher profit rates imply weaker competition, these findings confirm the results from Section 5 as well as the theory from Section 3: the effect of a marginal increase in capacity utilization on the probability of a price increase falls substantially with the degree of competition that a product faces. However, regarding the size of the marginal effects, there are remarkable differences between the results from Sections 5 and 6. Whereas the marginal effect for a very high degree of price competition, $\epsilon = 4$, is about equal to the marginal effect for the 10th percentile of the profit rate distribution (0.00029 compared to 0.00033), the marginal effects for lower degrees of price competition, $\epsilon = 3, 2, 1$, are more than twice as big as the marginal effects for the 40th, 60th and 90th percentile of the profit rate distribution (0.00110 compared to 0.00047, 0.00133 compared to 0.00057, 0.00199 compared to 0.00088). Consequently, the rise in the marginal effect from $\epsilon = 1$ to $\epsilon = 4$ is more than two times higher than the rise in the marginal effect from the 10th to the 90th percentile of the profit rate distribution.

Figure 4 displays the estimated effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on the probability of a price increase, $P(\pi_{it} = 1)$, for different percentiles of the sample distribution over the profit rate variable, Π_i . In contrast to Table 16, the marginal effect is not only evaluated at the sample mean of \tilde{K}_{it} , but over the full range of capacity utiliza-

tion. As before, the evaluation for each level of capacity utilization occurs at the sample means of the other covariates. Figure 4 confirms the findings of Table 16 for the full range of capacity utilization: prices of products, that generate higher profit rates, are more likely to increase in response to increases in capacity utilization, as compared to prices of products, that generate lower profit rates. Further, Figure 4 reveals that the marginal effect is increasing in capacity utilization, where the increase is the stronger the higher the profit rate is, i.e. the lower the degree of competition is. For instance, the marginal effect for products generating relatively high profit rates, $\Pi_i = 0.695$, which corresponds to the 90th percentile of the profit rate distribution, nearly triples from about 0.00043 for half capacity usage, $\tilde{K}_{it} = 50$, to about 0.00125 for full capacity usage, $\tilde{K}_{it} = 100$.³⁷ In contrast, the marginal effect for products generating relatively low profit rates, $\Pi_i = 0.143$, which corresponds to the 10th percentile of the profit rate distribution, just increases by about 70% from about 0.00024 for half capacity usage to about 0.00049 for full capacity usage.³⁸ In sum, not only are prices of products, which generate higher profit rates, hence, face weaker competition, more likely to increase in response to increases in capacity utilization, compared to prices of products which generate lower profit rates, hence, face stronger competition. But the *likelihood of a price increase rises with the actual level of capacity utilization*; and the higher is the profit rate, hence, *the lower is the competition, the stronger will be this rise*. Just as Table 16, Figure 4 reveals remarkable size differences compared to the results from Section 5. Apart from that, the forementioned findings confirm the conclusions from the last section.

Table 18 focuses on the probability of a price increase, $P(\pi_{it} = 1)$, rather than on marginal effects. As shown in column 1, for average capacity usage, $\tilde{K}_{it} = 81.82$, the probability of a price increase is hardly increasing with the profit rate. Not surprisingly, the probabilities in this column are never significantly different from each other at conventional levels (not shown). In contrast, for full capacity usage, $\tilde{K}_{it} = 100$, the probability of a price increase is increasing with the profit rate, hence, decreasing in the degree of competition (see column 2 of Table 18), where each probability is significantly different from the others at the 10 percent level (not shown). Further, the change in the probability of a price increase as capacity moves from average to full usage is also increasing with the profit rate, thus, decreasing in the degree of competition (see column 3 of Table 18), where again each change in probability is significantly different from the other changes at the 5 percent level. These results support the findings from Section 5. However, the size of the effects differs again remarkably from the size of the effects in the last section: whereas the probabilities for a very high degree of price competition, $\epsilon = 4$, are about

³⁷The tripling is in line with the result from Section 5.

³⁸The corresponding increase in Section 5 was even much weaker. At the time being, I have no explanation for this.

equal to – or at least not far from – the probabilities for the 10th percentile of the profit rate distribution (see the last row of Table 7 compared to the first row of Table 18), the probabilities for higher degrees of price competition are increasingly higher than the corresponding probabilities for lower profit rate levels (see the third row of Table 7 compared to the second row of Table 18, the second row of Table 7 compared to the third row of Table 18, and the first row of Table 7 compared to the last row of Table 18). For instance, at full capacity usage, the probability of price increase for a very low degree of price competition is nearly twice as high as the probability of price increase for a very high profit rate (0.114 compared to 0.0589).

In sum, the results of Figure 4 and Tables 16 to 18 confirm the results from Section 5: the lower the profit rate, thus, the higher the competition, the lower is the slope of the micro Phillips curve, i.e. the weaker is the product-specific link between inflation and economic activity. Moreover, the slope of the micro Phillips curve is increasing in the level of economic activity, and more so for products which generate higher profit rates, hence, face lower competition.

In the following, I repeat the analysis for prices decreases. Table 19 displays the estimated effect of a marginal decrease in capacity utilization, \tilde{K}_{it} , on the probability of a price decrease, $P(\pi_{it} = -1)$, at the 10th, 40th, 60th and 90th percentile of the sample distribution over the profit rate variable, Π_i . As before, the marginal effects are always evaluated at the sample mean of capacity utilization, $\tilde{K}_{it} = 81.92$, and at the sample means of the other covariates. In line with the theory, the marginal effect increases steadily with the profit rate, hence, it decreases with the degree of competition. Also, each marginal effect is significantly different from the others at the 5 percent level (not shown). Hence, when employing profit rates as a proxy for competition instead of the direct measure from Section 5, I get clear evidence that prices, which face higher competition, decrease less in response to decreases in capacity usage, as compared to prices, which face lower competition. The differences are substantial; for instance, the marginal effect for the 90th percentile of the profit rate distribution, hence, for very low competition, is about two and a half times higher than the marginal effect for the 10th percentile of the profit rate distribution, hence, for very high competition.

Figure 5 shows the estimated effect of a marginal decrease in capacity utilization, \tilde{K}_{it} , on the probability of a price decrease, $P(\pi_{it} = -1)$, at the 10th, 40th, 60th and 90th percentile of the sample distribution over the profit rate variable, Π_i . As before, the evaluation for each level of capacity utilization occurs at the sample means of the other covariates. The figure confirms the results from Table 19 over the full range of capacity usage: the higher the profit rate, hence, the weaker the competition, the stronger is the

effect of a marginal decrease in capacity usage on the probability of a price decrease; also, the marginal effect decreases with the level of capacity utilization and this decrease is substantially stronger for prices of products which generate higher profit rates, hence, face lower competition, compared to prices of products which generate lower profit rates, hence, face stronger competition.

Table 20 focuses on the probability of a price decrease, $P(\pi_{it} = -1)$, rather than on marginal effects. For average capacity usage, $\tilde{K}_{it} = 81.92$, the probability of a price decrease does not change with the profit rate variable, Π_i (see column 1). In contrast, as suggested by the theory, for half capacity usage, the probability of a price decrease increases steadily in the profit rate, hence, it decreases in the degree of price competition (see column 2). Also, each probability turns out to be significantly different from all other probabilities at the 10% level at least (not shown). The very same holds true for the change in the probability of a price decrease as capacity moves from average to half usage (see column 3 of Table 20).

In sum, the results of Figure 5 and Tables 19 to 20 stand in contrast to the findings from Section 5 on price decreases. The former convincingly support the theory from Section 3, but the latter do not. Hence, my findings seem only to be robust as regards price increases, but less so as regards price decreases.³⁹

7 Conclusion

An increasing number of researchers promotes to study price dynamics on a micro level (see Maćkowiak and Smets, 2008, amongst others). The reason for this being the idea that the richness and great variation on the micro level will help us to better answer the following questions. Are prices sticky? If so, why are prices sticky? What determines how sticky prices are? Eventually, micro level studies may help us to learn about the factors that determine, how neutral money is with respect to real outcomes, and how successful policy makers can be in stimulating or stabilizing the business cycle. Once we know these factors, we may also know whether/how we can influence them improve the effectiveness of business cycle policy. Following this route, I study the competition among firms as one factor of price stickiness. On the theoretical side, I develop a micro Phillips curve, i.e. a product-specific relation between inflation, inflation expectations and economic activity. This allows me to study – on the product level – how the degree of competition affects the slope of the micro Phillips curve, i.e. the response of inflation to marginal changes in economic activity, conditional on price expectations. I find two opposing effects. On the

³⁹I find that the results in this section are robust to the inclusion of industry dummy variables.

one hand, stronger competition leads to a higher frequency of price revaluations, implying a steeper slope. On the other hand, the stronger is the competition, the less pricing power firms have, and the less they can transmit changes in economic activity into price changes, implying a flatter slope. On the empirical side, I employ a unique product-level data panel including information on inflation, inflation expectations, capacity utilization, firms' rating of the degree of price competition, that a product faces, and profit rates as an alternative proxy for the level of competition. I find that the latter of the aforementioned effects clearly dominates and is an important factor for price stickiness. A stronger degree of competition weakens the link between inflation and economic activity substantially. The effect of a marginal increase in capacity utilization on the likelihood of a price increase is between 63% and 85% lower for products, that face very strong competition, compared to products facing very weak competition. In boom times, the effect is even between 70% and 96% lower. Notably, prices of products, that face very strong competition, are also less likely to *decrease* in response to marginal *decreases* in economic activity. This may seem counterintuitive, but is fully in line with the theory outlined in Section 3. For instance, in times of economic downturn, the effect of a marginal decrease in capacity utilization on the likelihood of a price decrease is between 71% and 89% lower for products, that face very strong competition, compared to products facing very weak competition. Moreover, I find that whether, and to what degree, the micro Phillips curve is non-linear, heavily depends on the degree of competition a product faces. In case of very weak competition, the higher (lower) the level economic activity already is, the higher will be the likelihood of a price increase (decrease) in response to marginal increases (decreases) in economic activity. This pattern gets weakened, when a product faces stronger competition. Eventually, for products facing very strong competition, the micro Phillips curve is statistically inexistent: even in times of economic boom (downturn), prices do not increase (decrease) in response to marginal increases (decreases) in economic activity. The findings of this study imply that high competition economies will be less prone to inflationary (deflationary) pressures in times of economic boom (downturn), compared to low competition economies. An important policy lesson is that structural competition policy and business cycle policy are related to each other: effective business cycle policy necessitates good competition policy. If policy makers want to be successful in stimulating or stabilizing the business cycle, they should engage in reforms that strengthen the competition in the economy. Another policy lesson is that stimulus or stabilization measures, which target specifically high competition firms or sectors, may be more effective than programs, which follow an indiscriminate all-round principle.

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Tables

Table 1: Survey questions and response categories

Variable	Question	Response Options			
<i>Qualitative proxy for product-specific sales transaction price inflation, $\pi_{i,t}$</i>	In the last three months the sales price in Swiss Francs you charge has ...	increased	remained unchanged	decreased	
<i>Qual. proxy for product-specific sales transaction price inflation expectation, $E_{i,t}[\pi_{i,t+1}]$</i>	In the next three months the sales price in Swiss Francs you charge will ...	increase	remain unchanged	decrease	
<i>Qualitative indicator of change in product-specific production capacity, $\Delta\tilde{K}_{i,t}$</i>	In the last three months the production capacities ...	increased	remained unchanged	decreased	
<i>Product-specific capacity utilization rate, $\tilde{K}_{i,t}$</i>	In the last three months the average capacity utilization rate was ...	50% 55% 60% ... 80% 95% 100%			
<i>Degree of price competition, $\epsilon_{i,t}$</i>	Judge the degree of price competition in the key sales market:	very weak	medium weak	medium strong	very strong

Notes: All questions relate to one specific good i produced by firm i in period t . The good is the principal good that the firm produces. If the firm produces more than one principal good, then the good is one of these goods. The first four variables come from the Quarterly KOF Business Tendency Survey. The last variable comes from the three-annually KOF Innovation Survey. Firms are asked to indicate the prices they (expect to) charge including discounts when actually selling their goods or placing a sales contract; they are explicitly asked not to indicate list prices. Production capacity comprises the good-specific manufacturing facilities excluding manpower. A capacity utilization rate of 100% corresponds to the full use of the product-specific manufacturing facilities given normal labor input. Shutdowns due to repairing shall not be reported as a reduction in capacity utilization. Firm i 's annual gross profit rate averaged over the years in the sample, Π_i , is derived from total revenue minus total costs divided by total costs, where total costs are the sum of labor costs and expenditures for commodities, material, intermediate goods and services.

Table 2: Summary statistics

Variable	No. obs.	Mean	Median	Std. Dev.	Freq. var. = ...		
					... 1	... 0	... -1
π_{it}	1654	-0.109	0	0.511	316	1204	134
$E_{it}[\pi_{i,t+1}]$	1654	-0.0295	0	0.511	241	1223	189
\tilde{K}_{it}	1654	81.93	85	12.58			
$\Delta\tilde{K}_{it}$	1654	0.0750	0	0.403	201	1376	77
ϵ_{it}	1654	3.18	3	0.900			
Π_{it}	1654	0.393	0.319	0.278			

Notes: These summary statistics relate to the sample used in Sections 5 and 6.

Figure 1: Degree of price competition over time



Notes: The solid line displays the average degree of price competition, ϵ_{it} , over time. The dashed lines display the upper and lower bound of the corresponding 90% confidence interval. The figure is based on all products for which ϵ_{it} is available and which figure in the panel in at least 5 out of 7 periods (this ensures a relatively balanced panel while keeping the number of products high). Similar patterns occur when including either all observations, no matter how often a product figures in the panel, or when including only the observations which figure in the regression sample.

Table 3: Empirical probability mass function across degree of price competition

		ϵ_{it}			
		1	2	3	4
Number of observations		94	265	541	754
Number of products		20	51	95	120
π_{it}	1	10.31%	6.13%	9.06%	8.06%
	0	82.47%	80.84%	76.34%	66.05%
	-1	7.22%	13.03%	14.60 %	25.89%

Notes: Statistics given in the table relate to the sample used in Sections 5 and 6.

Table 4: Ordered logistic regression

	Inflation, π_{it}
Inflation expectation, $E_{it}[\pi_{i,t+1}]$	1.711*** (0.145)
Capacity utilization rate, \tilde{K}_{it}	0.0313** (0.0129)
Capacity change, $\Delta\bar{K}_{it}$	-0.109 (0.154)
Dummy for medium weak degree of price competition, ϵ_2	-0.487 (1.359)
Dummy for medium strong degree of price competition, ϵ_3	0.180 (1.233)
Dummy for very strong degree of price competition, ϵ_4	1.059 (1.201)
$\tilde{K}_{it} \times \epsilon_2$	0.000283 (0.0166)
$\tilde{K}_{it} \times \epsilon_3$	-0.00697 (0.0151)
$\tilde{K}_{it} \times \epsilon_4$	-0.0223 (0.0148)
Number of observations	1654
Number of products	264
Pseudo R-squared	0.211

Notes: Taylor and period dummies are included in the regression, but not shown in the table. Taylor dummies are jointly significant. Period dummies are also jointly significant. Dummy for very weak degree of price competition, ϵ_1 , and interaction term $\tilde{K}_{it} \times \epsilon_1$ serve as reference categories, hence, they are excluded from the regression. Following Huber (1967) and White (1980, 1982), estimation of standard errors is robust to violation of assumption that observations and errors are identically distributed. Huber-White standard errors are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Effect of marginal increase in \tilde{K}_{it} on $P(\pi_{it} = 1)$ for $\epsilon_{it} = 1, 2, 3, 4$

ϵ_{it}	$dP(\pi_{it} = 1)/d\tilde{K}_{it}$	std. err.	t stat.	p value	90% C.I.
1	0.00199**	0.00096	2.08	0.037	(0.00042, 0.00357)
2	0.00133***	0.00049	2.73	0.006	(0.00053, 0.00214)
3	0.00110***	0.00039	2.83	0.005	(0.00046, 0.00173)
4	0.00029	0.00025	1.17	0.243	(-0.00012, 0.00070)

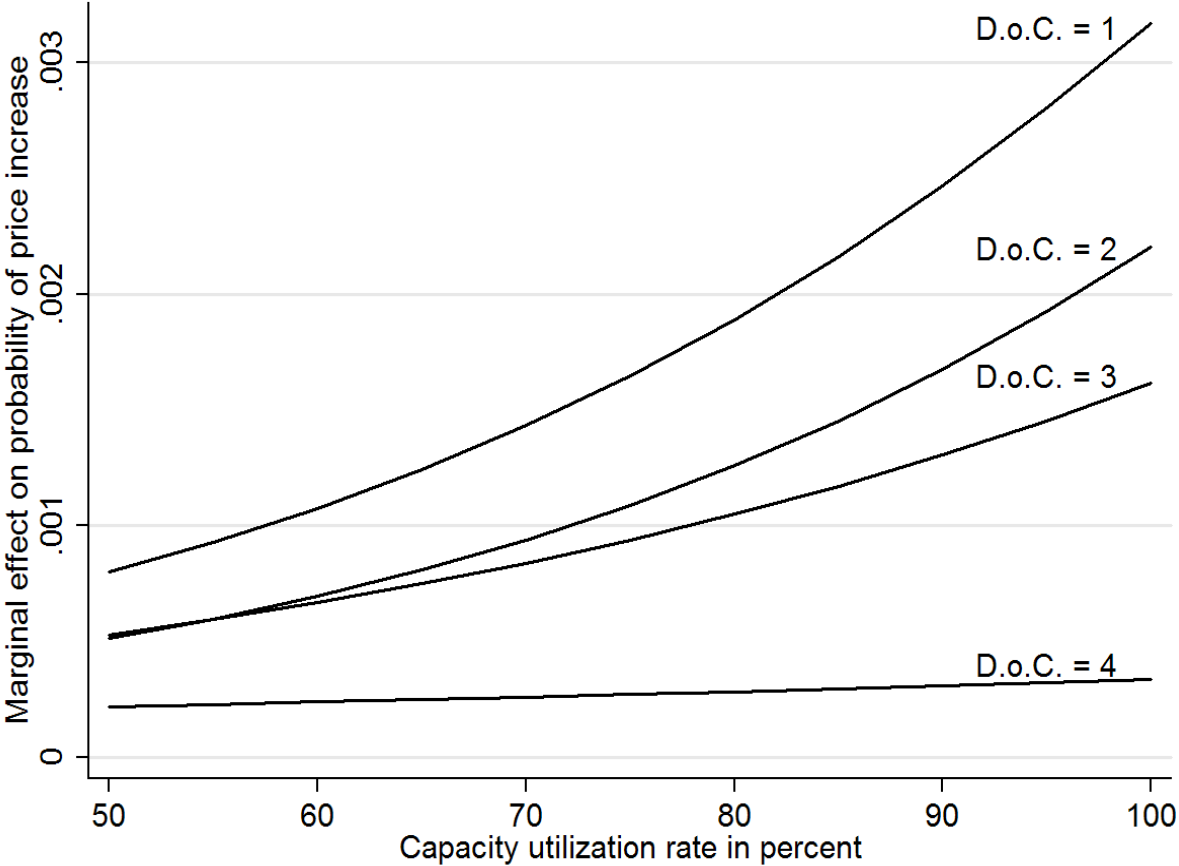
Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 6: p values for test that $dP(\pi_{it} = 1)/d\tilde{K}_{it}|_{\epsilon_{it}=n}$ equals $dP(\pi_{it} = 1)/d\tilde{K}_{it}|_{\epsilon_{it}=m}$, where $n = 1, 2, 3$, $m = 2, 3, 4$ and $n \neq m$

		ϵ_{it}		
		1	2	3
ϵ_{it}	2	0.534		
	3	0.381	0.694	
	4	0.0838*	0.0535*	0.0739*

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 2: Marginal effect of \tilde{K}_{it} on $P(\pi_{it} = 1)$ over \tilde{K}_{it} for $\epsilon_{it} = 1, 2, 3, 4$



Notes: This figure displays the estimated effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on the probability of a price increase, $P(\pi_{it} = 1)$, over the full range of capacity utilization for the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$. D.o.C. means degree of price competition, ϵ_{it} .

Table 7: Effect of an increase from average to full capacity usage on $P(\pi_{it} = 1)$ for $\epsilon_{it} = 1, 2, 3, 4$

ϵ_{it}	$P(\pi_{it} = 1) _{\tilde{K}_{it}=81.92}$	$P(\pi_{it} = 1) _{\tilde{K}_{it}=100}$	$P(\pi_{it} = 1) _{\tilde{K}_{it}=100} - P(\pi_{it} = 1) _{\tilde{K}_{it}=81.92}$
1	0.0680*** (0.000)	0.114*** (0.001)	0.0464* (0.0782)
2	0.0439*** (0.000)	0.0755*** (0.000)	0.0316** (0.0258)
3	0.0471*** (0.000)	0.0715*** (0.000)	0.0244** (0.0161)
4	0.0330*** (0.000)	0.0387*** (0.000)	0.00570 (0.278)

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. p values in brackets refer to test against H_0 that effect is zero. *** p<0.01, ** p<0.05, * p<0.1

Table 8: p values for test that $P(\pi_{it} = 1)|_{\epsilon_{it}=n, \tilde{K}_{it}=l}$ equals $P(\pi_{it} = 1)|_{\epsilon_{it}=m, \tilde{K}_{it}=l}$, where $n = 1, 2, 3$, $m = 2, 3, 4$, $n \neq m$ and $l = 81.92, 100$

		Degree of price competition, ϵ_{it}					
		$\tilde{K}_{it} = 81.92$			$\tilde{K}_{it} = 100$		
		1	2	3	1	2	3
ϵ_{it}	2	0.108			0.311		
	3	0.151	0.662		0.244	0.841	
	4	0.0148**	0.0941*	0.0125**	0.0336**	0.0383**	0.0172**

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 9: p values for test that $P(\pi_{it} = 1)|_{\epsilon_{it}=n, \tilde{K}_{it}=100} - P(\pi_{it} = 1)|_{\epsilon_{it}=n, \tilde{K}_{it}=81.92}$ equals $P(\pi_{it} = 1)|_{\epsilon_{it}=m, \tilde{K}_{it}=100} - P(\pi_{it} = 1)|_{\epsilon_{it}=m, \tilde{K}_{it}=81.92}$, where $n = 1, 2, 3$, $m = 2, 3, 4$, $n \neq m$

		ϵ_{it}		
		1	2	3
ϵ_{it}	2	0.619		
	3	0.435	0.671	
	4	0.129	0.0838*	0.0965*

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 10: Effect of marginal decrease in \tilde{K}_{it} on $P(\pi_{it} = -1)$ for $\epsilon_{it} = 1, 2, 3, 4$

ϵ_{it}	$-dP(\pi_{it} = -1)/d\tilde{K}_{it}$	std. err.	t stat.	p value	90% C.I.
1	0.00230**	0.00097	2.37	0.018	(0.00389, 0.00070)
2	0.00336***	0.00120	2.81	0.005	(0.00533, 0.00139)
3	0.00245***	0.00083	2.95	0.003	(0.00382, 0.00108)
4	0.00120	0.00100	1.19	0.232	(0.00284, -0.00045)

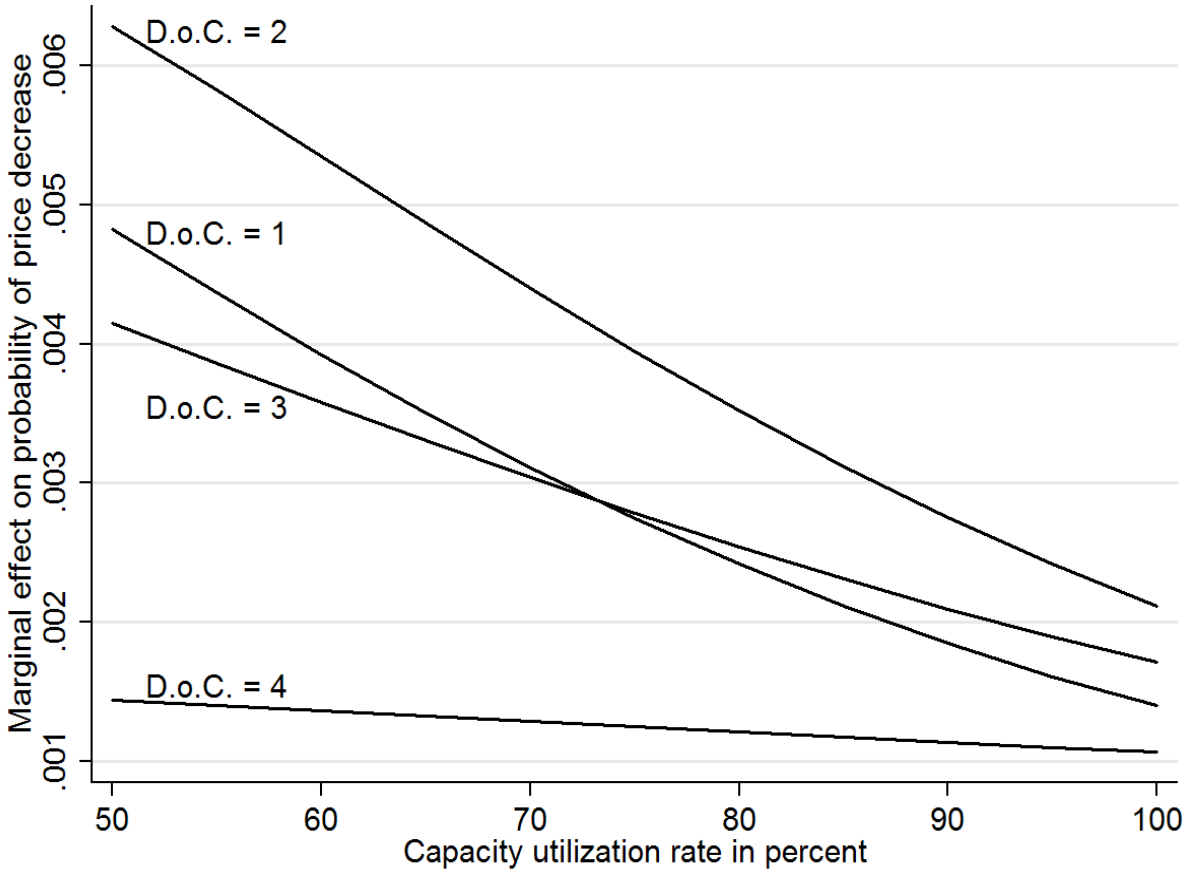
Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 11: p values for test that $-dP(\pi_{it} = -1)/d\tilde{K}_{it}|_{\epsilon_{it}=n}$ equals $-dP(\pi_{it} = -1)/d\tilde{K}_{it}|_{\epsilon_{it}=m}$, where $n = 1, 2, 3$, $m = 2, 3, 4$ and $n \neq m$

		ϵ_{it}		
		1	2	3
ϵ_{it}	2	0.487		
	3	0.905	0.527	
	4	0.426	0.163	0.330

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 3: Marginal effect of \tilde{K}_{it} on $P(\pi_{it} = -1)$ over \tilde{K}_{it} for $\epsilon_{it} = 1, 2, 3, 4$



Notes: This figure displays the estimated effect of a marginal decrease in capacity utilization, \tilde{K}_{it} , on the probability of a price decrease, $P(\pi_{it} = -1)$, over the full range of capacity utilization for the different degrees of price competition, $\epsilon_{it} = 1, 2, 3, 4$. D.o.C. means degree of price competition, ϵ_{it} .

Table 12: Effect of a decrease from average to half capacity usage on $P(\pi_{it} = -1)$ for $\epsilon_{it} = 1, 2, 3, 4$

ϵ_{it}	$P(\pi_{it} = -1) _{\tilde{K}_{it}=81.92}$	$P(\pi_{it} = -1) _{\tilde{K}_{it}=50}$	$P(\pi_{it} = -1) _{\tilde{K}_{it}=50} - P(\pi_{it} = -1) _{\tilde{K}_{it}=81.92}$
1	0.0798*** (0.000)	0.191*** (0.004)	0.111* (0.0770)
2	0.121*** (0.000)	0.274*** (0.000)	0.153** (0.0274)
3	0.114*** (0.000)	0.218*** (0.000)	0.104** (0.0184)
4	0.157*** (0.000)	0.198*** (0.000)	0.0421 (0.275)

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. p values in brackets refer to test against H_0 that effect is zero. *** p<0.01, ** p<0.05, * p<0.1

Table 13: p values for test that $P(\pi_{it} = -1)|_{\epsilon_{it}=n, \tilde{K}_{it}=l}$ equals $P(\pi_{it} = -1)|_{\epsilon_{it}=m, \tilde{K}_{it}=l}$, where $n = 1, 2, 3$, $m = 2, 3, 4$, $n \neq m$ and $l = 81.92, 50$

		Degree of price competition, ϵ_{it}					
		$\tilde{K}_{it} = 81.92$			$\tilde{K}_{it} = 50$		
		1	2	3	1	2	3
ϵ_{it}	2	0.0552*			0.398		
	3	0.0744*	0.673		0.736	0.516	
	4	0.0002**	0.0613*	0.0085***	0.914	0.366	0.755

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 14: p values for test that $P(\pi_{it} = -1)|_{\epsilon_{it}=n, \tilde{K}_{it}=50} - P(\pi_{it} = -1)|_{\epsilon_{it}=n, \tilde{K}_{it}=81.92}$ equals $P(\pi_{it} = -1)|_{\epsilon_{it}=m, \tilde{K}_{it}=50} - P(\pi_{it} = -1)|_{\epsilon_{it}=m, \tilde{K}_{it}=81.92}$, where $n = 1, 2, 3$, $m = 2, 3, 4$ and $n \neq m$

		ϵ_{it}		
		1	2	3
ϵ_{it}	2	0.650		
	3	0.933	0.549	
	4	0.347	0.160	0.283

Notes: ϵ_{it} denotes the degree of price competition which product i faces at time t . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 15: Ordered logistic regression

	Inflation, π_{it}
Inflation expectation, $E_{it}[\pi_{i,t+1}]$	1.624*** (0.147)
Capacity utilization rate, \tilde{K}_{it}	0.00521 (0.00757)
Capacity change, $\Delta\bar{K}_{it}$	-0.115 (0.161)
Profit rate, Π_i	-2.0864** (-2.00)
$\tilde{K}_{it} \times \Pi_i$	0.0258** (0.0123)
Number of observations	1654
Number of products	264
Pseudo R-squared	0.216

Notes: Taylor and period dummies are included in the regression, but not shown in the table. Taylor dummies are jointly significant. Period dummies are also jointly significant. Following Huber (1967) and White (1980, 1982), estimation of standard errors is robust to violation of assumption that observations and errors are identically distributed. Huber-White standard errors are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 16: Effect of marginal increase in \tilde{K}_{it} on $P(\pi_{it} = 1)$ over Π_i

Π_i percentile	$dP(\pi_{it} = 1)/d\tilde{K}_{it}$	std. err.	t stat.	p value	90% C.I.
10	0.00033	0.00024	1.39	0.165	(-0.00006, 0.00073)
40	0.00047**	0.00021	2.25	0.025	(0.00013, 0.00082)
60	0.00057***	0.00020	2.90	0.004	(0.00025, 0.00090)
90	0.00088***	0.00023	3.80	0.000	(0.00050, 0.00126)

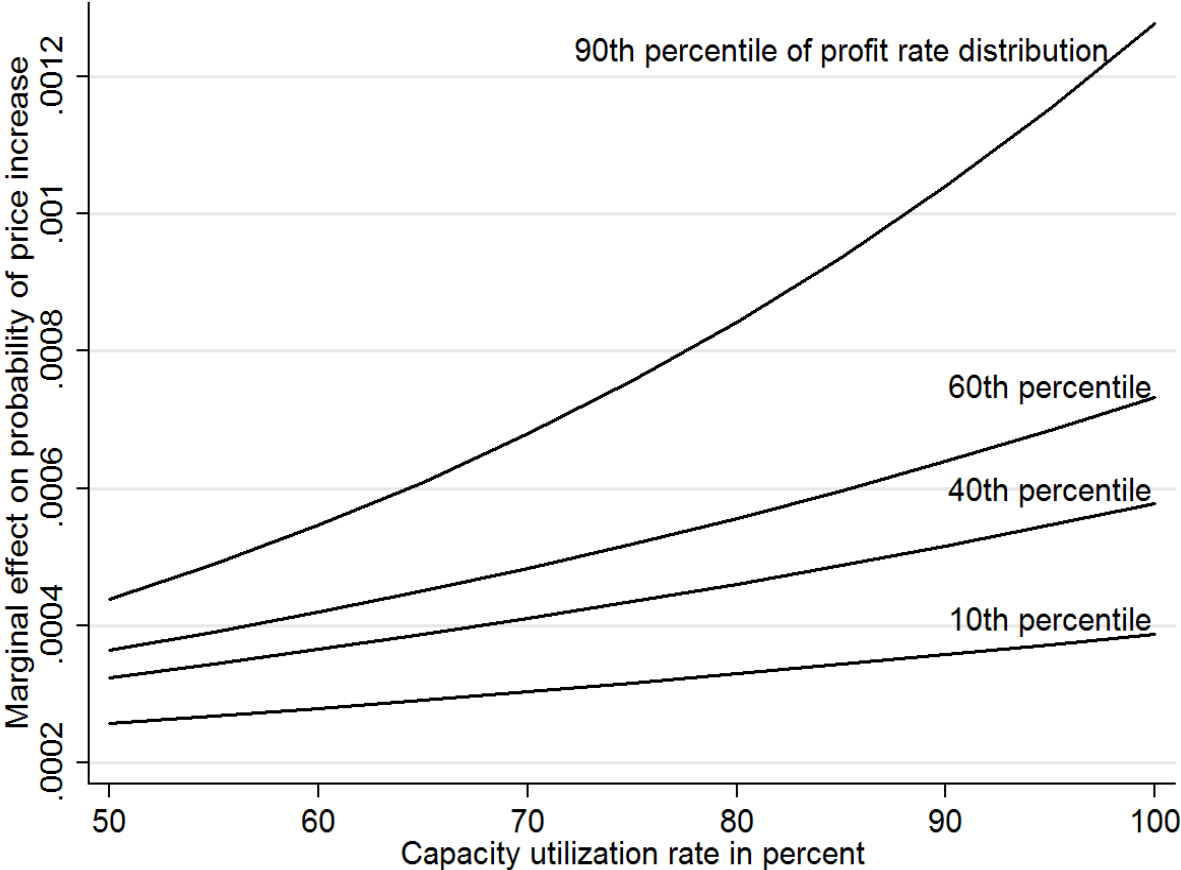
Notes: Π_i denotes firm i 's annual gross profit rate averaged over the years in the sample. Π_i -percentile = n or Π_t -percentile = m denotes n th or m th percentile of the sample distribution over Π_i . $\Pi_i = 0.143$ (0.282, 0.384, 0.695) is the 10th (40th, 60th, 90th) percentile of the distribution over Π_i . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 17: p values for test that $dP(\pi_{it} = 1)/d\tilde{K}_{it}|_{\Pi_i\text{-percentile}=n}$ equals $dP(\pi_{it} = 1)/d\tilde{K}_{it}|_{\Pi_i\text{-percentile}=m}$, where $n = 10, 40, 60$, $m = 40, 60, 90$ and $n \neq m$

		Π_i -percentile		
		10	40	60
Π_i -percentile	40	0.0368**		
	60	0.0368**	0.0372**	
	90	0.0384**	0.0399**	0.0414**

Notes: Π_i denotes firm i 's annual gross profit rate averaged over the years in the sample. Π_i -percentile = n or Π_t -percentile = m denotes n th or m th percentile of the sample distribution over Π_i . $\Pi_i = 0.143$ (0.282, 0.384, 0.695) is the 10th (40th, 60th, 90th) percentile of the distribution over Π_i . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 4: Effect of marginal increase in \tilde{K}_{it} on $P(\pi_{it} = 1)$ over \tilde{K}_{it} and Π_i



Notes: This figure displays the estimated effect of a marginal increase in capacity utilization, \tilde{K}_{it} , on the probability of a price increase, $P(\pi_{it} = 1)$, over the full range of capacity utilization for the 10th, 40th, 60th and 90th percentile of the sample distribution over Π_i .

Table 18: Effect of an increase from average to full capacity usage on $P(\pi_{it} = 1)$ over Π_i

Π_i -perc.	$P(\pi_{it} = 1) _{\tilde{K}_{it}=81.92}$	$P(\pi_{it} = 1) _{\tilde{K}_{it}=100}$	$P(\pi_{it} = 1) _{\tilde{K}_{it}=100} - P(\pi_{it} = 1) _{\tilde{K}_{it}=81.92}$
10	0.0393*** (0.000)	0.0458*** (0.000)	0.00652 (0.195)
40	0.0394*** (0.000)	0.0488*** (0.000)	0.00945** (0.0409)
60	0.0394*** (0.000)	0.0512*** (0.000)	0.0117*** (0.0093)
90	0.0396*** (0.000)	0.0589*** (0.000)	0.0193*** (0.0011)

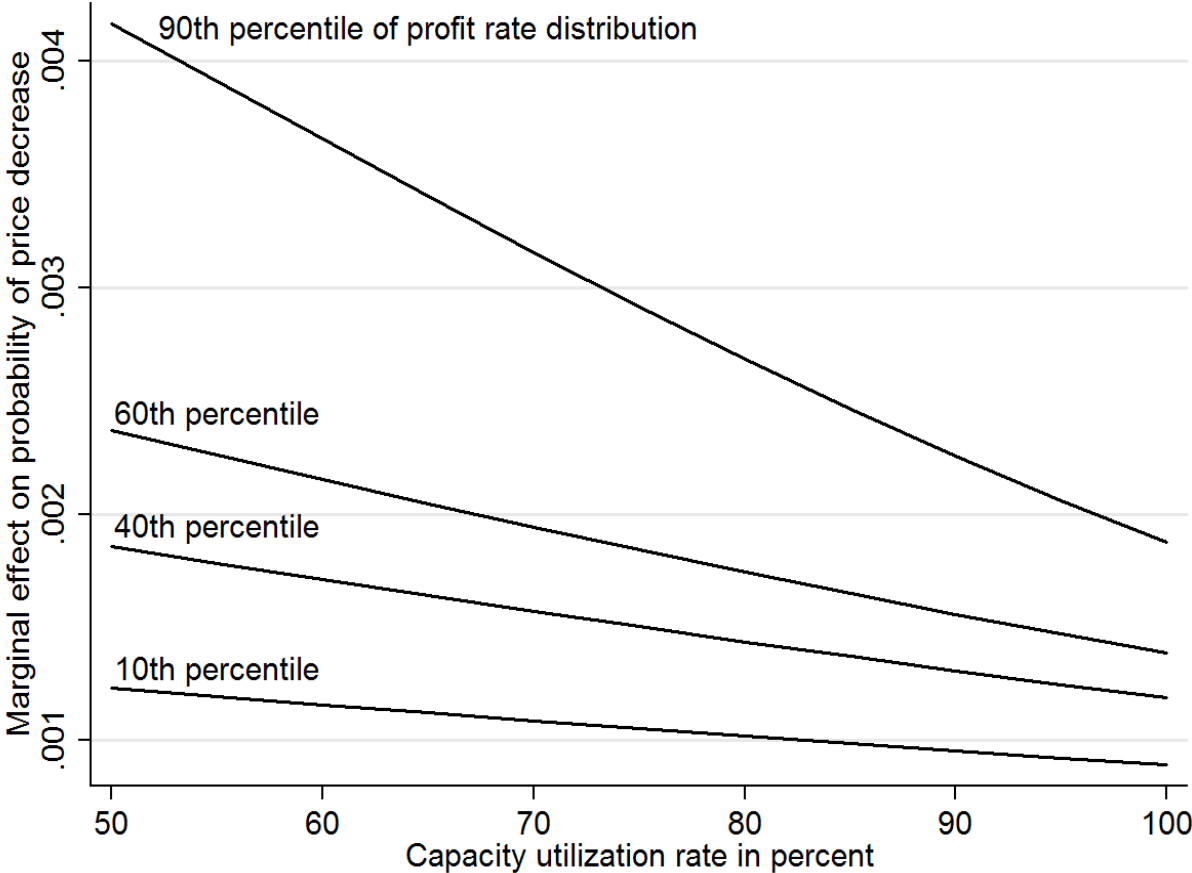
Notes: Π_i denotes firm i 's annual gross profit rate averaged over the years in the sample. Π_i -perc. = n or Π_t -perc. = m denotes n th or m th percentile of the sample distribution over Π_i . $\Pi_i = 0.143$ (0.282, 0.384, 0.695) is the 10th (40th, 60th, 90th) percentile of the distribution over Π_i . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. p values in brackets refer to test against H_0 that effect is zero. *** p<0.01, ** p<0.05, * p<0.1

Table 19: Effect of marginal decrease in \tilde{K}_{it} on $P(\pi_{it} = -1)$ over Π_i

Π_i percentile	$dP(\pi_{it} = 1)/d\tilde{K}_{it}$	std. err.	t stat.	p value	90% C.I.
10	0.00101	0.00072	1.40	0.163	(0.00220, -0.00018)
40	0.00141**	0.00061	2.30	0.022	(0.00242, 0.00040)
60	0.00171***	0.00057	3.02	0.003	(0.00264, 0.00078)
90	0.00260***	0.00065	4.00	0.000	(0.00367, 0.00153)

Notes: Π_i denotes firm i 's annual gross profit rate averaged over the years in the sample. Π_i -percentile = n or Π_t -percentile = m denotes n th or m th percentile of the sample distribution over Π_i . $\Pi_i = 0.143$ (0.282, 0.384, 0.695) is the 10th (40th, 60th, 90th) percentile of the distribution over Π_i . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Figure 5: Effect of marginal decrease in \tilde{K}_{it} on $P(\pi_{it} = -1)$ over \tilde{K}_{it} and Π_i



Notes: This figure displays the estimated effect of a marginal decrease in capacity utilization, \tilde{K}_{it} , on the probability of a price decrease, $P(\pi_{it} = 1)$, over the full range of capacity utilization for the 10th, 40th, 60th and 90th percentile of the sample distribution over Π_i

Table 20: Effect of a decrease from average to half capacity usage on $P(\pi_{it} = -1)$ over Π_i

Π_i -perc.	$P(\pi_{it} = -1) _{\tilde{K}_{it}=81.92}$	$P(\pi_{it} = -1) _{\tilde{K}_{it}=50}$	$P(\pi_{it} = -1) _{\tilde{K}_{it}=50} - P(\pi_{it} = -1) _{\tilde{K}_{it}=81.92}$
10	0.130*** (0.000)	0.166*** (0.000)	0.0357 (0.204)
40	0.130*** (0.000)	0.182*** (0.000)	0.0520** (0.0433)
60	0.130*** (0.000)	0.195*** (0.000)	0.0648*** (0.0094)
90	0.130*** (0.000)	0.237*** (0.000)	0.107*** (0.0010)

Notes: Π_i denotes firm i 's annual gross profit rate averaged over the years in the sample. Π_i -perc. = n or Π_t -perc. = m denotes n th or m th percentile of the sample distribution over Π_i . $\Pi_i = 0.143$ (0.282, 0.384, 0.695) is the 10th (40th, 60th, 90th) percentile of the distribution over Π_i . π_{it} denotes the pricing decision of firm i w.r.t. product i at time t . \tilde{K}_{it} denotes the capacity utilization rate for product i at time t . Evaluation is at means of covariates unless stated otherwise. p values in brackets refer to test against H_0 that effect is zero. *** p<0.01, ** p<0.05, * p<0.1