Capacity Utilisation, Constraints and Price Adjustments under the Microscope

Sarah M. Lein and Eva Köberl

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July 13, 2009

Abstract

This paper analyses the interplay of capacity utilisation, capacity constraints, demand constraints and price adjustments, employing a unique firm-level data set for Swiss manufacturing firms. Theoretically, capacity constraints limit the ability of firms to expand production in the short run and lead to increases in prices. Our results show that, on the one hand, price increases are more likely during periods when firms are faced with capacity constraints. Constraints due to the shortage of labour, in particular, lead to price increases. On the other hand, we also find evidence that firms are not reluctant to reduce prices in response to demand constraints. At the macro level, the implied capacity-utilisation Phillips curve has a convex shape during periods of excess demand and a concave shape during periods of excess supply. Our results are robust to the inclusion of proxies for changes in costs and the competitive position of firms.

JEL classification: E31; E32; E52

Keywords: price setting, capacity utilisation, capacity constraints, demand constraints, non-linear Phillips curve, Switzerland.

1 Introduction

Measures for capacity utilisation rates have long been used as a determinant for upcoming inflationary pressures and therefore are a useful tool for monetary policy. Central banks use these measures to enable them to calculate future risks to price stability and therefore react in a forward looking manner. However, the relationship between the rate of capacity utilisation and inflation is not necessarily linear. If capacity constraints limit the ability of firms to meet cyclical increases in the overall level of demand, the short-run relationship between output and inflation will tend to have a curved shape, with inflation becoming more sensitive to changes in output when the cycle of economic activity is high than when it is low (MacKlem, 1997). Empirical estimates that impose linearity might therefore over- or underestimate the inflationary risk of the current state of the business cycle. Failures to account for non-linearity might thus have strong implications for monetary policy reaction functions. If Phillips curves are non-linear, this implies that monetary policy makers operating with a linear Taylor type rule create a welfare loss (Laxton et al., 1999). The central question for empirical models therefore is: Do capacity constraints put additional pressure on prices? And, if so, is the impact of such constraints on prices sizeable? So far, several studies have investigated the non-linearity in the relationship between real activity and inflation using macroeconomic variables. However, as compared to the theoretical literature, empirical research has produced mixed findings.[1] One reason for such mixed findings might be that capacity constraints cannot be observed directly in macroeconomic time series on capacity utilisation rates. Researchers have usually included a squared term of the output gap or a kinked functional form, assuming that the slope of the Phillips

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[1]The most intensively studied country is the U.S. For example, Gordon (1997) and Yates (1998) find that the U.S. Phillips curve is linear. On the contrary, Debelle and Laxton (1996) and Clark et al. (2001) conclude that the U.S. Phillips curve is convex. Filardo (1998) finds evidence that it is convex-concave. Similar mixed results are reported for European countries. For example, Dolado et al. (2005) and Baghli et al. (2007) provide some evidence for the relevance of non-linearity in the euro area Phillips curve, while Musso et al. (2007) find no significant evidence of non-linearity.

curve in excess supply situations differs from that in excess demand situations. Thus, the common practice is to assume that firms experience capacity constraints during periods of very high real activity. This, however, raises the question: Even if a non-linearity is found in macro data, are the sources of the steeper Phillips curve during periods of high real activity really capacity constraints?[2] There cannot be a clear-cut answer to this without observing capacity constraints directly. Furthermore, as we will show in the micro data, there exists a substantial degree of heterogeneity across firms. This is also a point that cannot be controlled for in studies employing macro data.

The aim of this paper, therefore, is to give answers to the questions raised above, by investigating the role of capacity utilisation and capacity constraints for the price-setting behaviour of firms using micro data. A unique panel dataset of quarterly data of Swiss manufacturing firm surveys from 1999-2007, conducted by the KOF Swiss Economic Institute, allows us to analyse the role of capacity constraints for the pricing behaviour of firms. There are two main advantages of utilising micro data. First, we can directly observe whether or not a firm is faced with a capacity constraint. Second, we can match the capacity utilisation rate and the presence of constraints to firms' pricing decisions and therefore account for the high degree of heterogeneity we find across firms. We find that high capacity utilisation does not necessarily correlate with the presence of constraints at the firm level. Some firms already indicate capacity constraints at capacity utilisation rates of 90 percent, whereas others indicate no capacity constraints at utilisation rates of 100 percent. Using aggregate series of capacity utilisation in the whole economy and a squared

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[2]There are alternative explanations for a convex Phillips curve. For example, Ball et al. (1988) show that, in the presence of menu costs, not all firms will change their prices in response to a particular demand shock. However, the more firms that decide to change their prices, the more responsive will be the aggregate price level to demand shocks. In their model, firms increase the frequency and size of price adjustment as inflation rises, so aggregate demand shocks will have less effect on output and more effect on the price level. Ball and Mankiw (1994) discuss another implication of menu costs. In the presence of trend inflation, prices should be more flexible upwards than downwards because some firms are able to obtain relative price declines from trend inflation without changing their own prices and incurring real costs. The model could thus imply a convex Phillips curve that becomes linear as inflation approaches zero. See Dupasquier and Ricketts (1998).

term as a proxy for capacity constraints might therefore lead to the mixed results found in previous studies. We find that firms that currently employ a higher than average use of their capacity are significantly more likely to increase prices, and the probability that they will decrease prices is lower. Furthermore, the existence of capacity constraints leads to a significantly higher probability of price increases. According to our estimates, a firm under constrained capacities due to the shortage of labour has a ten percent higher probability of increasing prices, and a firm that indicates capacity constraints due to restrictions in technical capacities has a six percent higher probability of raising prices. These estimates are conditional on holding capacity utilisation at the average.

In this paper, especially in the theoretical section, we mainly focus on periods of excess demand. When the Phillips curve is otherwise linear and only convex in regions of large excess demand, this would imply that the sacrifice ratio is higher during periods of excess supply than the output gains of inflation during excess demand periods.[3] Such a convex Phillips curve is illustrated in Figure 1. Hence, this would give a rationale for central banks to fight inflation more aggressively during periods of overheating, as the gains in terms of output of allowing for higher inflation are lower than the cost of bringing inflation back to the target. This would imply that asymmetric policy rules for convex Phillips curves, as proposed by Schaling (2004), are appropriate for monetary policy making.

However, what matters for policy conclusions is also the shape of the curve during periods of excess supply, because this is the measure of the cost of bringing inflation back to the target in terms of output. Hence, an additional important question is: How much output has to be sacrificed to reduce inflation? Theoretically, there is no clear cut answer to this question. On the one hand, output costs of bringing inflation down might be high because of downward nominal price rigidity (Akerlof et al., 1996). On the other hand, output costs might be low: A theoretical model put forward by Stiglitz (1984) shows

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[3]The sacrifice ratio is defined as the cost of disinflation in terms of output.

that, in monopolistically competitive markets, firms are less threatened by the entry of potential competitors in a recession and hence charge higher prices than they do during boom phases. In expansions, the firms in the market keep prices down to avoid the entrance of competitors. Therefore, the price level is less sensitive to a positive shock to demand than to a negative shock. Such pricing behaviour would imply that the Phillips curve is concave. In the empirical part of this paper, we therefore also analyse the impact of demand constraints on prices at the firm level. We find that the presence of such constraints has a strong impact on prices. Firms are more likely to decrease prices and less likely to increase prices under demand constraints - the probability of a price reduction is roughly 60 percent higher, holding all other variables at their average. These findings suggest that the output costs of reducing inflation are relatively low. Hence, we find both higher responsiveness in prices to capacity constraints *and* to demand constraints, compared to situations when firms are not faced with constraints. At the macro level, this implies that the Phillips curve is steeper during periods of high real activity and steeper during periods of very low real activity. When looking at the Phillips curve in a traditional diagram with excess supply and excess demand plotted against the left and right-hand side of the x-axis, respectively, and the change in inflation on the y-axis, the shape of the Phillips curve is convex-concave, a result also shown in Filardo (1998). Such a Phillips curve is illustrated in Figure 2. In this kind of economy, a convexity exists at high levels of capacity utilisation, where many firms are faced with capacity constraints. Nevertheless, due to concavity in a situation of excess supply, reducing inflation once it deviates from the target is not that costly in terms of output.

The remainder of the paper is structured as follows. Section 2 briefly summarises the literature on the capacity constraint model and non-linear Phillips curves. In Section 3, a theoretical model is described. Section 4 gives details about the data and the methodology used for the empirical analysis, Section 5 presents the estimation results, Section 6 conducts

robustness checks and Section 7 concludes.

2 Related Literature

The rate of capacity utilisation has long been recognised as an explanatory variable for inflation. Many studies have ascertained the predictive power of the degree of capacity utilisation for forecasting inflation. For example, Stock and Watson (1999) report that capacity utilisation outperforms the traditional measure of unemployment as a predictor of inflation in a Phillips curve estimation. Theoretical models that link the degree of capacity utilisation to inflation include, amongst others, Greenwood et al. (1988), Burnside et al. (1993), and Cooley et al. (1995). These models, however, do not consider situations of capacity constraints, mainly for practical reasons. Nevertheless, capacity constraints are important: if firms operate near their capacity constraint, any increase in demand can hardly be met by increased production. As such, in the short run, the increase in demand translates almost uniquely into an increase in prices. Hence, at the macro level, in a situation where many firms operate close to their capacity constraint, a relatively small aggregate demand shock would lead to a large increase inflation. Thus, the Phillips curve is almost vertical near the level of economic activity where all firms are capacity constrained, where the slope becomes gradually steeper as the economy moves in the direction of the (aggregate) capacity constraint. The capacity constraint model implies a vertical asymptote in the Phillips curve at the capacity constraint (De Veirman, 2007). Such a convex short-run Phillips curve under capacity constraints is illustrated in Figure 1.

Several studies tested for non-linearity in the Phillips curve employing macro data, i.e. data on inflation and measures of real economic activity. However, no consensus seems to prevail as regards the most appropriate specification of the relationship. Turner (1995) em-
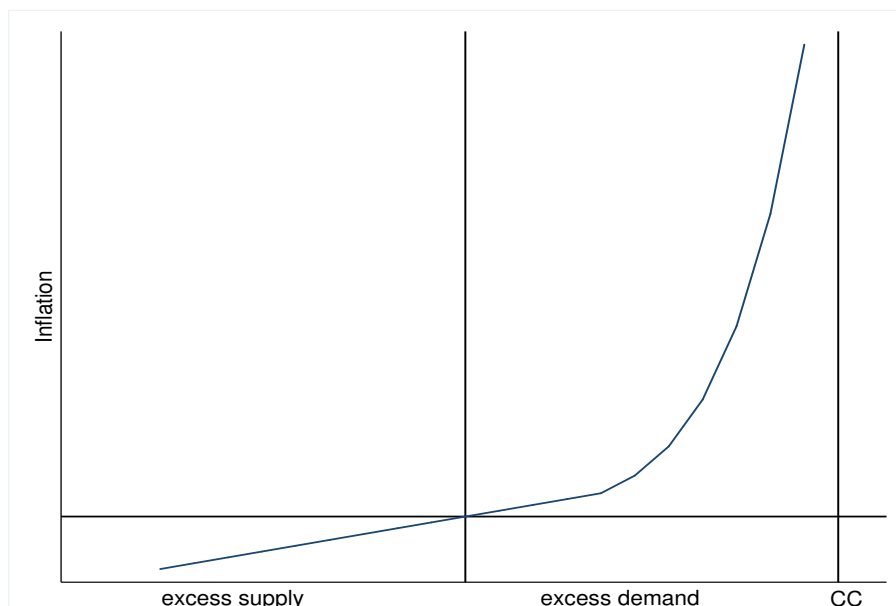
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Figure 1: A convex Phillips curve under the capacity constraint hypothesis.
CC denotes the point where all firms in the economy are capacity constrained.

ploys a kinked specification of the Phillips curve equation for the G7 countries individually, and finds significant asymmetric effects from the output gap, with inflationary effects of positive gaps being larger than the deflationary effects of negative gaps for Canada, Japan, and the US. Notably, he cannot reject the linear model for the European countries, France and Germany. Clark et al. (1996) also estimate a kinked line for the US Phillips curve. They found evidence for convexity in US data from 1964 to 1990. Laxton et al. (1995) and Clark et al. (1996, 2001) include a quadratic term of the output gap in their Phillips curve specification and find support for convexity. By contrast, Gordon (1997) rejects the hypothesis of non-linearity for the US data over the period 1955 to 1996. Filardo (1998) concludes that the Phillips curve is convex-concave with inflation accelerating faster during periods of strong excess demand, a moderate acceleration of inflation during periods of moderate real activity and a stronger decline of inflation during periods of excess supply. Figure 2 illustrates such a short-run convex-concave Phillips curve.

A direct test of the capacity constraint hypothesis is so far missing in the literature,

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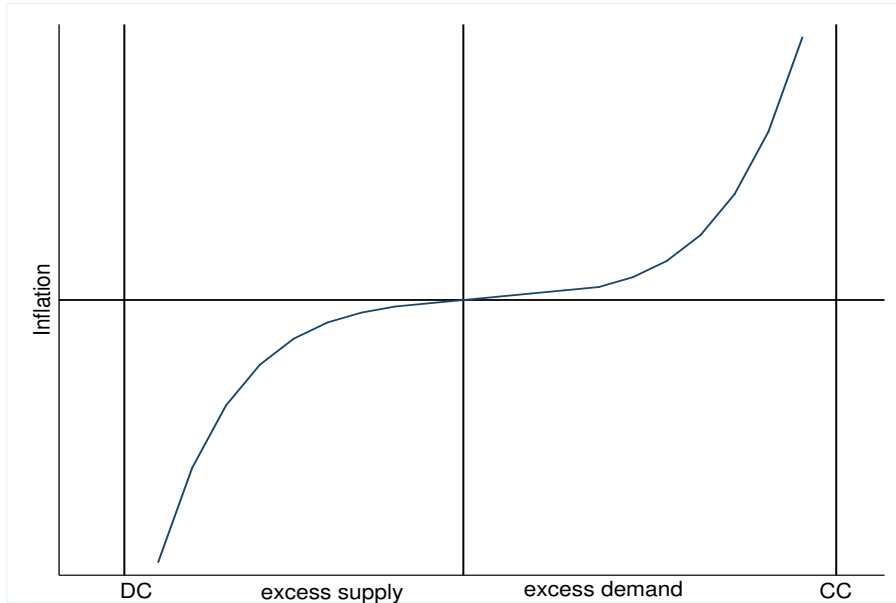
Figure 2: A convex-concave Phillips curve under the capacity constraint hypothesis with demand constraints.

CC denotes the point where all firms in the economy are capacity constrained, CD the point where all firms are demand constrained.

mainly due to the fact that it has not been possible to directly observe the presence of capacity constraints. This paper fills this gap by employing micro data that contain such direct information, so that tests for the capacity constraint hypothesis can be carried out.

3 The Model

In this section, we describe the theoretical model developed by Álvarez Lois (2004), which shows that a convex Phillips curve can exist if firms are faced with capacity constraints. First, following Fagnart et al. (1999), it is shown that the assumption of the existence of capacity constraints and demand uncertainty allows for differences in capacity utilisation across firms. Second, the production side of this economy is combined with a sticky price assumption. The result is that the dynamics of inflation depend on the distribution of constraints across firms in the economy. A New Keynesian-type Phillips curve is derived

that exhibits a convex shape if capacity constraints are present.[4] We present the Álvarez-Lois model to obtain a testable price-setting equation for our empirical model.

The economy is described by an intermediate goods producing sector and a final goods producing sector. The intermediate goods sector is characterised by monopolistic competition whereas the final goods sector operates in a competitive environment. Idiosyncratic demand uncertainty in the intermediate goods sector introduces heterogeneity, which determines the degree of capacity utilisation in equilibrium.[5]

3.1 Final Goods Producers

Final goods are produced by employing a continuum of intermediate goods, $j \in [0, 1]$. The final goods Y at time t are produced by a representative firm in a perfectly competitive market with a constant elasticity of substitution (CES) technology

$$Y_t = [\int_0^1 Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} dj]^{\frac{\epsilon}{\epsilon-1}} \tag{1}$$

where $Y_{j,t}$ is the intermediate good j used in production and $\nu_{j,t} > 0$ is the productivity parameter of input j, which is assumed to be i.i.d. distributed across input firms and to be serially uncorrelated. ϵ represents the elasticity of substitution. The distribution function $F(\nu)$ with unit mean and variance σ_ν is defined over the support $[0, \infty)$ and is assumed to be log normal. The representative final goods producer purchases inputs in the intermediate goods sector. The total supply of input j is limited to an amount $\bar{Y}_{j,t}$, equal to the maximum productive capacity of the corresponding input supplying firm.

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[4]Another theoretical microfoundation for such a relationship is given in the capacity constraint model of Evans (1985). This model relies upon the assumption that firms find it difficult to increase their production capacity in the short run. Due to bottlenecks in the production process, inflation accelerates more during periods of high aggregate demand than during periods of low demand. Hence, the model also implies a convex short-run aggregate supply/Phillips curve.

[5]We model the production side of the economy only, as the effect of capacity constraints on price adjustments is the main focus of the empirical part of this paper. A fully fledged general equilibrium model can be found in Álvarez Lois (2006).

Intermediate firms operate in a market with monopolistic competition with sticky prices. Thus, if they are not constrained, intermediate goods producers satisfy demand at posted prices. Prices are readjusted in a Calvo-type fashion. If the capacity constraint is binding for intermediate goods producers, they sell only the maximum quantity they can supply ($\bar{Y}_{j,t}$), and thus do not satisfy all demand. Thus, there is rationing, and the quantity sold is lower than demand for the intermediate product at the posted price. The maximisation problem of intermediate goods producers will be discussed more thoroughly in the following section.

The final goods producer knows input prices $\{P_{j,t}\}$, the supply constraints $\bar{Y}_{j,t}$ and the realisations of the productivity parameter $\{\nu_{j,t}\}$. The final goods producer, who does not face uncertainty, maximises profits subject to the supply constraints in intermediate products $Y_{j,t} < \bar{Y}_{j,t}$. Hence, the optimisation problem can be written as follows

$$\max_{Y_{j,t}} \mathbf{P}_t Y_t - \int_0^1 P_{j,t} Y_{j,t} dj, \tag{2}$$

subject to $Y_{j,t} < \bar{Y}_{j,t}, \forall j \in [0,1]$. $\mathbf{P}_t$ is the final goods price and Y_t is defined by equation (1).

The first order conditions of this simple maximisation problem are

$$Y_{j,t} = \begin{cases} Y_t \nu_{j,t} (\frac{P_{j,t}}{\mathbf{P}_t})^{-\epsilon} & \text{if } \nu_{j,t} \leq \tilde{\nu}_{j,t} \\ \bar{Y}_{j,t} & \text{if } \nu_{j,t} \geq \tilde{\nu}_{j,t} \end{cases} \tag{3}$$

which determine demand for the intermediate good j at time t. The Appendix provides more details on the derivation.

$$\tilde{\nu}_{j,t} = \frac{\bar{Y}_{j,t}}{Y_t (\frac{P_{j,t}}{\mathbf{P}_t})^{-\epsilon}} \tag{4}$$

represents the critical value of the productivity shock for which the unconstrained demand

equals the maximum supply $\bar{Y}_{j,t}$.

As intermediate good producers are identical ex ante, $\bar{Y}_{j,t} = \overline{Y}_t$, $P_{j,t} = \mathbf{P}_t$ and there is symmetry in capacities and prices. The latter implies that $\tilde{\nu}_{j,t}$ is identical across all intermediate good j producing firms. Inserting (3) and (4) into (1) yields final goods supply

$$Y_t = \{[Y_t(\frac{P_{j,t}}{\mathbf{P}_t})^{-\epsilon}]^{\frac{\epsilon-1}{\epsilon}} \int_0^{\widetilde{\nu}_t} \nu dF(\nu) + (\overline{Y_t})^{\frac{\epsilon-1}{\epsilon}} \int_{\widetilde{\nu}_t}^{\infty} \nu^{\frac{1}{\epsilon}} dF(\nu)\}^{\frac{\epsilon}{\epsilon-1}}. \tag{5}$$

This expression follows from the fact that the productivity shock is *below* $\widetilde{\nu}_t$ for a proportion $F(\widetilde{\nu}_t)$ of inputs, which therefore are not supply-constrained. The proportion $1 - F(\widetilde{\nu}_t)$ is above $\widetilde{\nu}_t$ and therefore is supply-constrained, purchasing only a quantity of $\overline{Y_t}$ of the intermediate good.

3.2 Intermediate Inputs Sector

The intermediate-goods sector is characterised by monopolistic competition. Prices are adjusted according to a Calvo-pricing rule. Each firm may reset its price only with probability $1 - \theta$ in any given period. Firms are assumed to set their prices before they know the realisation of the demand shock, i.e. intermediate goods producers start with a predetermined level of capacity at time t.[6] This uncertainty implies that all firms that receive the Calvo signal in period t set the same price P_t^* by solving the following problem

$$\max_{P_t^*} \sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\Delta_{t+k} E_\nu\{Y_{t+k}^{int}\}[P_t^* - MC_{t+k}]\} \tag{6}$$

subject to the expected demand from final goods producers

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[6]We assume that it is not possible for intermediate goods producers to maintain falsely that they are capacity constrained once the demand shock is observed.

$$E_\nu\{Y_{t+k}^{int}\} = (\frac{P_t^*}{\mathbf{P}_{t+k}})^{-\epsilon}Y_{t+k}\int_0^{\widetilde{\nu}_{t+k}^t}\nu dF(\nu) + \overline{Y}_t\int_{\widetilde{\nu}_{t+k}^t}^\infty dF(\nu) \qquad (7)$$

where $\beta\Delta_{t+k}$ corresponds to the stochastic discount factor for nominal payoffs[7] and $MC_{t+k} \equiv \frac{W_{t+k}}{A_{t+k}}$ is the marginal cost of production with W_{t+k} being the nominal wage and A_{t+k} the productivity measure from the Cobb-Douglas production function. Expected demand for the intermediate good in period $t + k$ is denoted by Y_{t+k}^{int}. Note that all intermediate input firms are ex ante identical and therefore set the same price P_t^*, thus we drop the index j. Expected demand is simply a result of the demand for the intermediate good defined by equation (3), weighted by the probability distribution of the productivity shock. Recall that $F(\nu)$ is the probability distribution of the productivity shock. Thus, for a proportion $F(\widetilde{\nu})$ of intermediate firms, the realised value of the productivity parameter is below $\widetilde{\nu}$.

The first-order condition associated with the problem above takes the following form

$$P_t^* = \frac{E_t\sum_{k=0}^\infty(\beta\theta)^k\Delta_{t+k}E_\nu\{Y_{t+k}^{int}\}MC_{t+k}\epsilon\Gamma(\widetilde{\nu}_{t+k}^t)}{E_t\sum_{k=0}^\infty(\beta\theta)^k\Delta_{t+k}E_\nu\{Y_{t+k}^{int}\}[\epsilon\Gamma(\widetilde{\nu}_{t+k}^t) - 1]} \qquad (8)$$

where

$$\Gamma(\widetilde{\nu}_{t+k}^t) \equiv \frac{\int_0^{\widetilde{\nu}_{t+k}^t}\nu dF(\nu)}{\int_0^{\widetilde{\nu}_{t+k}^t}\nu dF(\nu) + \widetilde{\nu}_{t+k}^t\int_{\widetilde{\nu}_{t+k}^{int}}^\infty dF(\nu)} \qquad (9)$$

is the probability that a firm that sets its price in t is faced with a demand in period $t + k$ that is smaller than the productive capacity of the given firm. Or, in other words, the probability that a firm is not constrained. The Appendix provides more details on the

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[7]In a general equilibrium setting, the stochastic discount factor corresponds to the representative household's relative valuation of cash across time. The subscript $t + 1$ takes into account the fact that shareholders of firms (households) can use the cash to buy consumption goods. As we focus on the Phillips curve relationship here, we do not explicitly model the consumption side of the economy. See Álvarez Lois (2000).

derivation of equation (8). Hence, $1 - \Gamma(\tilde{\nu}_{t+k}^{int})$ is a measure for the share of intermediate goods producers that are faced with stronger demand than their actual production capacity supplies.

For log-linearisation around the steady state, the flexible price (i.e. for $\theta = 0$) and the optimal price without constraints (i.e. $1 - \Gamma(\tilde{\nu}_{t+k}^{int}) = 0$) are given by

$$\mathbf{P}_t = \frac{\epsilon\Gamma(\tilde{\nu}_{t+k}^{int})}{\epsilon\Gamma(\tilde{\nu}_{t+k}^{int}) - 1}\frac{W_t}{A_t} \tag{10}$$

and

$$\mathbf{P}_t = \frac{\epsilon}{\epsilon - 1}\frac{W_t}{A_t} \tag{11}$$

respectively.

3.3   The Phillips Curve

Log-linearizing the first order condition (8) around the steady state yields

$$\widehat{P}_t^* = (1 - \beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k[\Theta_{t+k}^c + \widehat{mc}_{t+k} + \widehat{P}_t] \tag{12}$$

where $\widehat{\Theta}_{t+k}^c$ is the log-linear approximation of $\frac{\epsilon\Gamma(\tilde{\nu}_{t+k}^{int})}{\epsilon\Gamma(\tilde{\nu}_{t+k}^{int})-1}$ and variables denoted with "$\widehat{}$" are written in terms of their percentage deviation from steady state. $\widehat{mc}_{t+k}$ is the log of the average real marginal cost, that is

$$\widehat{mc}_{t+k} = \widehat{W}_t - \widehat{P}_t - \widehat{z}_t \tag{13}$$

with $\widehat{z}_t \equiv log(\frac{A_t}{A})$.

Solving equation (12) forward yields

$$\widehat{P}_t^* = (1 - \beta\theta)[\Theta_t^c + \widehat{mc}_t + \widehat{P}_t] + (\beta\theta)\widehat{P}_{t+1}^*. \tag{14}$$

13

This is a central equation of the model as it relates the price-adjustment decision of firms to the capacity constraints the firms are currently faced with. This is the equation we are going to take to the data in the empirical part of the paper. Before doing so, we show that this model implies a convex Phillips curve at the aggregate level if capacity constraints are present.

Given that a share of θ firms updates the price in a given period, the aggregate input price index evolves according to

$$\mathbf{P}_t = [\theta P_{t-1}^{1-\epsilon} + (1-\theta)(P_t^*)^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \tag{15}$$

or in log-linear form

$$\widehat{P}_t = \theta \widehat{P}_{t-1} + (1-\theta)\widehat{P}_t^*. \tag{16}$$

Combining price setting with aggregate price dynamics yields the Phillips curve

$$\pi_t = \beta E_t \pi_{t+1} + \lambda(\widehat{\Theta}_t^c + \widehat{mc}_t) \tag{17}$$

with $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$.

In this expression the inflation rate depends not only on the deviation of marginal cost from steady state but also on the term $\widehat{\Theta}_t^c$, which measures the share of firms in the economy that operate at full capacity. Presumably, in reality such capacity constraints are more likely to arise during periods of strong aggregate demand. Hence, at the macro level, during periods of high real activity, more and more firms are capacity constrained, i.e. the term $\widehat{\Theta}_t^c$ becomes > 0 and thereby puts additional upward pressure on inflation.

The implications of this kind of convex Phillips curve for macroeconomic policy would provide the motivation for stabilising output around its potential and avoiding larger deviations from it. Monetary policymakers need to be more aggressive in fighting inflation

during periods of strong excess demand, as bringing inflation back to the initial level is more costly than the benefits from the initial increase. Therefore, monetary policy has to be more forward-looking and it is more important to be aware of the current state of the business cycle.

It should be noted here that we employ the Álvarez-Lois model as a workhorse, showing how capacity constraints can arise and feed through to inflation theoretically. Directly relating the data employed here to the model has some shortcomings that need to be borne in mind. In particular, Calvo pricing is assumed, because making price adjustments state-dependent yields very complicated dynamics that are far beyond the scope of this paper. Nevertheless, we would like to mention that state-dependent adjustments would yield a theoretical model that could be related more directly to the data employed here, as this would make it possible to relate the presence of capacity constraints to the frequency of price adjustments. The contribution of this paper is clearly in the application of micro data that allow for the observation of both price adjustments and capacity constraints at the firm level. Hence, in the empirical section, we test the validity of the assumption that firms' price setting behaviour takes capacity constraints into account. Furthermore we look at the effect of demand constraints and analyse whether we find more downward pressure on prices during those periods, to test for downward rigidity. Hence, Calvo pricing is a simplification to make the theoretical model tractable. In the empirical section, we take into account state-dependent pricing.

4   Data and Methodology

4.1   Data

For our analysis we use firm level micro data. The data source is a quarterly business-tendency survey in the manufacturing industry as conducted by the KOF Swiss Economic

Institute. For our estimations we employ all observations from 1999 onwards, because the information on the presence of constraints is available only since then (see below). The estimation sample therefore consists of $25,608$ observations of $1,966$ firms in an unbalanced panel. Relating to prices, there are several qualitative questions in the survey. Firms are asked whether their selling prices (i) have been changed in the previous three months (denoted by $Sellingprice_{it}$ for firm i at period t), and (ii) whether they will be changed in the following three months, $E_t(Sellingprice_{i,t+1})$. The answering options on both questions are increase (+1), decrease (-1) or left unchanged (0), whereas a non-response is treated as missing value. Relating to capacity utilisation, the firms are asked to quantify the capacity utilisation ($Utilisation_{it}$) within the past three months in percentage points, with the firms able to choose from a range of 50% to 110% in five percent steps.[8] From the latter we can calculate the percentage change in production capacity from $t-1$ to t ($Change\ in\ Utilisation_{it-1,t}$). We control for the change in utilisation, as it is likely that firms undertake utilisation adjustments in response to shocks as an alternative to price adjustments (e.g. Andersen and Toulemonde, 2004). For example, Müller and Köberl (2007) show that changes in capacity utilisation rates are used as an adjustment mechanism in response to demand shocks. From 1999 onwards, the survey also includes qualitative questions about production barriers. Firms can indicate whether they are restricted by constraints. Namely, unsatisfactory demand ($Demandconstraint_{it}$), or one of two types of capacity constraints, which are (i) capacity constraints due to insufficient technical capacities ($TechnicalCapconstraint_{it}$)[9] and (ii) capacity constraints due to

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[8]In the survey questionnaire, it is stated that capacity utilisation is defined as physical capacity alone: Buildings, plant, machinery, vehicles etc. Firms are asked to define a capacity utilisation of 100 percent as a situation where they use all their capital during general working hours and the usual number of shifts. A situation where firms claim above 100 percent utilisation may thus be given in the case when firms use all their capital for more than the usual working hours, or when all capital is used with an additional shift.

[9]The survey questionnaire states that firms should indicate if their production is constrained, and, if so, whether it is due to the shortage of technical capacity, such as machines, vehicles etc.

labour shortage[10] ($LabourCapconstraint_{it}$)(amongst others not considered in this paper). Hence, $TechnicalCapconstraint_{it}$ and $LabourCapconstraint_{it}$ are proxies for the presence of short-run capacity constraints. $Demandconstraint_{it}$ is the indicator for demand constraints.[11]

Obtaining a measure of the deviation of a firm's current utilisation from a value that is regarded as "normal" can be challenging. It is a common practice to employ the long-term average of capacity utilisation as the natural rate. However, different firms display quite different long-term averages of utilisation rates. The distribution of long-term utilisation rates across firms, i.e. the average of all observations, by firm, over the estimation sample, is shown in Figure 3. In Figures 4 and 5, we plot the distribution of capacity utilisation rates of firms, conditioning on a restriction in technical capacities and labour supply, respectively. As can be seen, the distribution becomes more left skewed, with more firms operating at higher capacity utilisation rates. This is theoretically plausible, as firms should stretch their utilisation rates as far as possible when faced with strong demand. Also, the distribution of capacity utilisation rates under demand constraints is theoretically plausible. As shown in Figure 6, the distribution is slightly right skewed, indicating that firms that are faced with demand constraints have already reduced capacity utilisation rates. One feature that becomes apparent in all graphs is that not all firms necessarily operate at high capacity utilisation when they indicate that they are faced with capacity constraints. A substantial proportion of capacity-constrained firms operates at 85 percent and below. For example, firms with only one to 49 employees have an average utilisation of 81.4 percent, whereas firms with more than 200 employees show an average utilisation of 85.8 percent. It is thus not always accurate to assume that capacity constraints arise only at very high utilisation rates. Also demand-constrained firms do not necessarily operate at very low utilisation

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[10]The survey questionnaire states that firms should indicate if their production is constrained, and, if so, whether it is due to the shortage of labour.

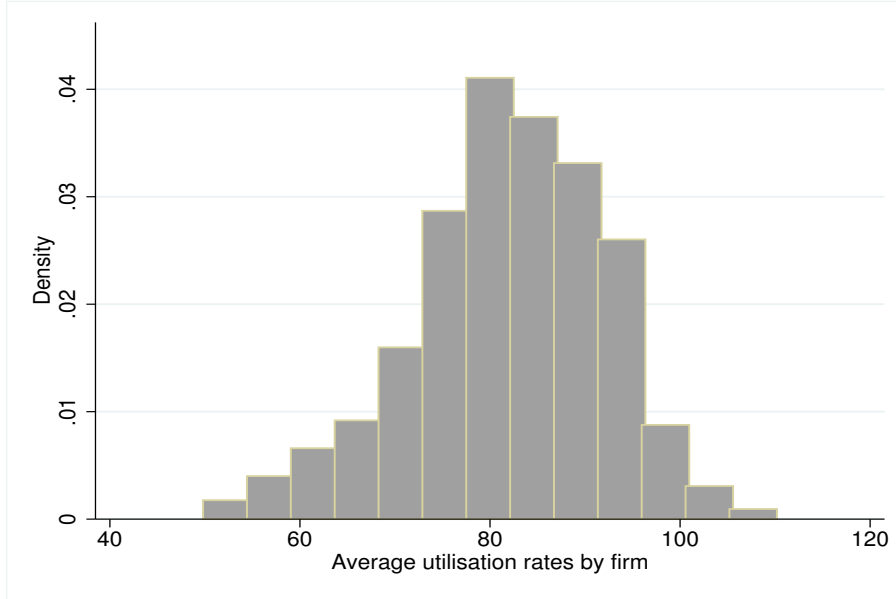[11]The base category is no constraint and other constraints.

Figure 3: Discrete distribution of average capacity utilisation rates across firms over time.
Source: KOF Quarterly Industry Survey.

rates. This again corroborates the motivation for this paper to employ directly observable
constraint indicators from micro data in order to examine the relationship to prices.

We therefore use the deviation of a firm's current from its firm-specific long-term average
utilisation as a proxy for the deviation from steady state utilisation. For calculating the
deviation of a firm from its individual average utilisation, we use the following relative
measure[12]

$$Gap_{i,t} = \frac{U_{i,t} - \frac{1}{T}\sum_{\tau=1}^{T} U_{i,\tau}}{\frac{1}{T}\sum_{\tau=1}^{T} U_{i,\tau}} \tag{18}$$

where $U_{i,t}$ is the capacity utilisation rate of firm i at time t. As a consequence of firms
answering on a voluntary basis, the observations for each firm are not uninterrupted over
time. Hence, we have an unbalanced panel and therefore use the index τ instead of t in

_____

[12]Note that if there are structural breaks at the firm level, such an "average" may be an insufficient
measure. As the main purpose of this paper is to analyse the impact of constraints, we abstract from the
case that structural breaks at the firm level exist. We take a more careful look at the utilisation rate that
is consistent with a theoretically-based zero-inflation steady state in Köberl and Lein (2008).
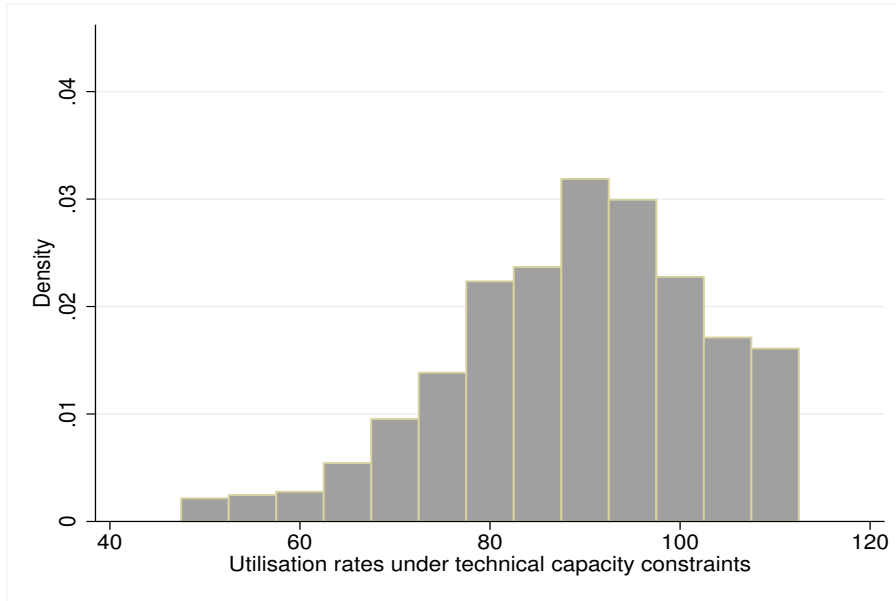
Figure 4: Discrete distribution of utilisation rates under technical capacity constraints.
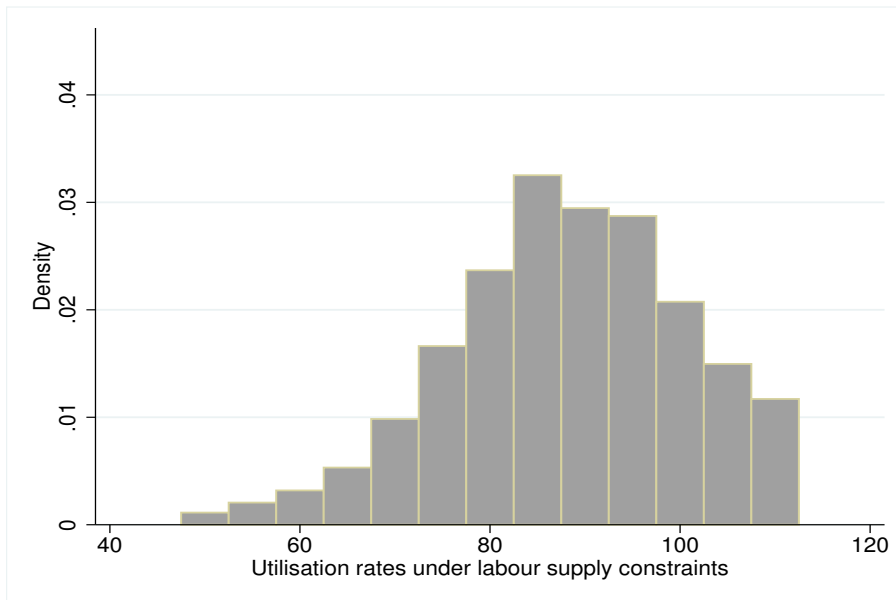Source: KOF Quarterly Industry Survey.

Figure 5: Discrete distribution of utilisation rates under capacity constraints due to shortage of labour.
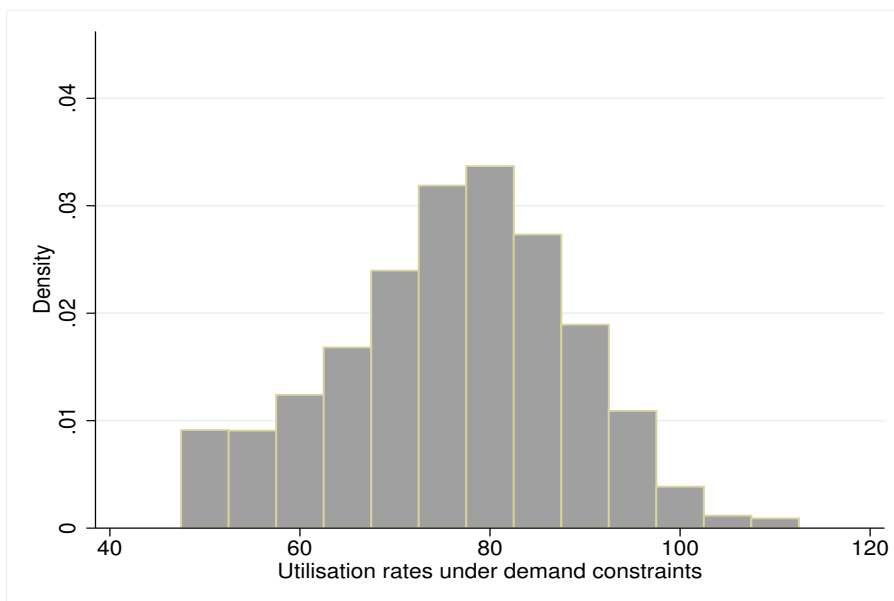Source: KOF Quarterly Industry Survey.

Figure 6: Discrete distribution of utilisation rates under demand constraints.
Source: KOF Quarterly Industry Survey.

the summation. The number of responding firms in each quarter fluctuates between 897 and 1,335.[13]

The average price increases and decreases in the previous quarter over time can be found in Figure 7. Price increases usually display spikes in the first quarter of each year. This observation is relatively standard in the empirical price-setting literature and is a form of Taylor pricing, where firms re-set their prices in regular intervals. The relatively large share of price increases in the first quarter 2001 is due to an increase in the rate of value added tax (VAT). Price decreases, on the other hand, do not appear to display seasonality. Furthermore, during the period from the second quarter of 2001 to the fourth quarter of 2005, we observe more price reductions than increases. As producer price inflation

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[13]We had the choice to either use an unbalanced panel and allow for fluctuations in the number of responding firms or to restrict the sample to firms that respond each quarter over the entire sample. The latter would leave us with a much lower number of observations. We therefore opted to use the unbalanced panel. However, we analysed the issue of fluctuations of respondents more thoroughly than reported here and we did not find that restricting the sample to a share of firms that respond regularly (and therefore to a more stable number of responding firms) would lead to results that were very different in qualitative terms.
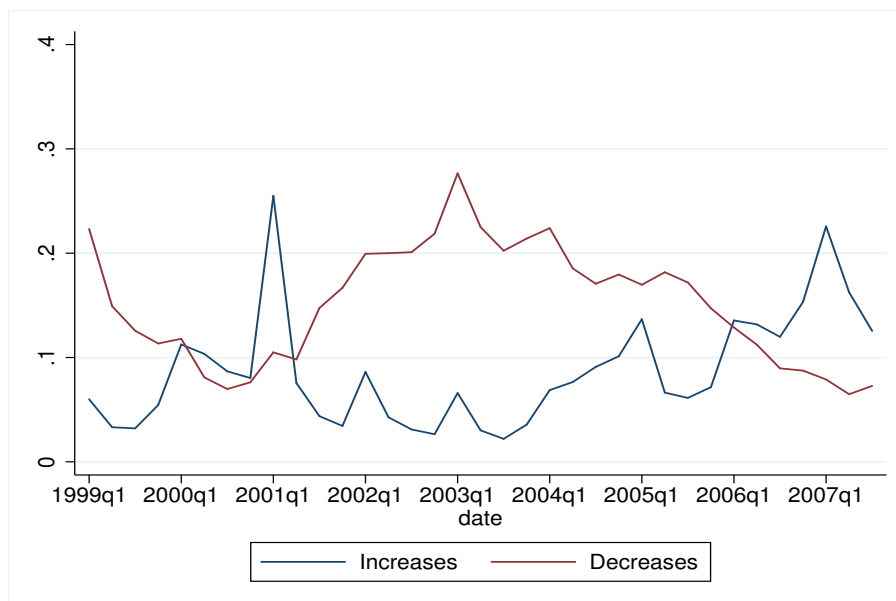
Figure 7: Percentage share of price increases and decreases in the previous quarter, over time.
Source: KOF Quarterly Industry Survey.

in Switzerland was only at 0.4 percent on average during that period, such a picture is plausible.

Figure 8 shows the price increases and decreases that are expected by firms for the upcoming quarter of each survey period. For expected price increases, a similar picture arises. The large spike in the last quarter of 2000 is likely to be driven by the expected increase in VAT rates in 2001.

A further survey description is given in Table 9 in the Appendix. Summary statistics of the estimation sample are provided in Table 10.

4.2 Methodology

The main assumption in the theoretical model that we would like to test is whether firms set prices by taking into account capacity constraints and real marginal cost (equation (14)). Hence, we model empirically the price adjustment probability as a function of two
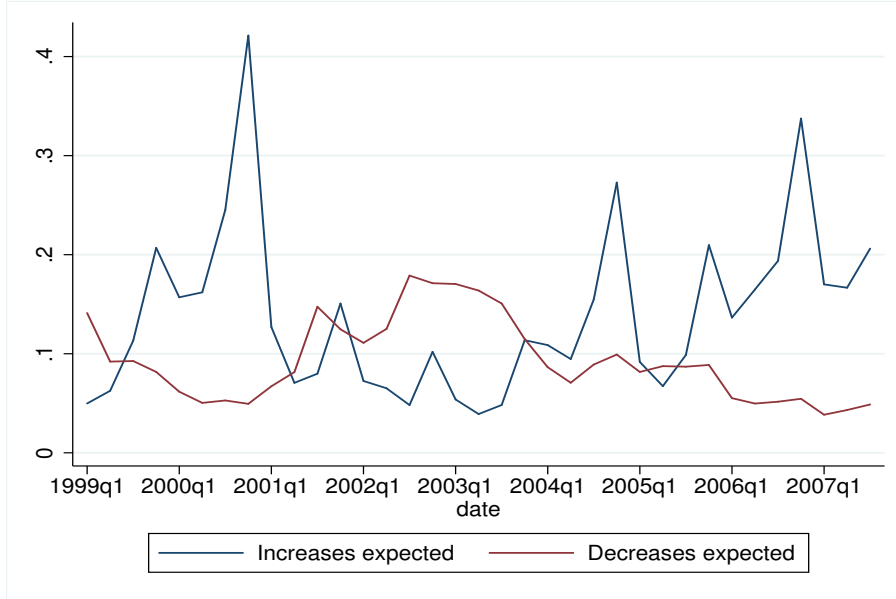
Figure 8: Percentage share of expected price increases and decreases in the forthcoming quarter, over time.
Source: KOF Quarterly Industry Survey.

variables: First, the capacity constraints firms are faced with, and, second, a measure of the deviation of real marginal cost from steady state. For the former we employ the binary variable indicating a capacity constraint, whereas for the latter we employ the capacity utilisation gap defined in equation 18 as a proxy.

The dependent binary variable y_{it} is defined as 1 if the price of the product produced by firm i has increased in the last three months and zero otherwise

$$y_{it}^+ = 1 \quad if \quad Selling\ price_{it} = 1 \tag{19}$$

$$y_{it}^+ = 0 \quad otherwise. \tag{20}$$

We follow Rupprecht (2007) and distinguish between price increases and decreases to investigate whether asymmetries play a role in price-setting behaviour, i.e. whether price

22

increases behave differently than price decreases in response to the explanatory variables. For modelling price reductions, the dependent variable is then defined as

$$
\begin{aligned}
y_{it}^- &= 1 \quad if \quad Selling\ price_{it} = -1 \\
y_{it}^- &= 0 \quad otherwise.
\end{aligned}
$$

(21)

(22)

We use the conditional logit model, where the probability that firm i changes its price in period t is given by

$$
P(y_{it} = 1 | x_{it}, \overline{y}_i) = \frac{exp(x_{it}'\beta)}{1 + exp(x_{it}'\beta)}.
$$

(23)

x_{it} are the explanatory variables at time t for firm i. $\overline{y}_i$ is the average of observed price adjustments conducted by firm i. As explanatory variables we include

- $Gap_{i,t}$: The capacity utilisation gap as defined in (18) serves as indicator for real activity (or, in terms of the New Keynesian model, the proxy for the deviation of real marginal cost from their steady state value).

- *Change in Utilis*: The percentage change of capacity utilisation $(U_{i,t} - U_{i,t-1})/U_{i,t-1}$.

- *Winter, spring, summer*: Seasonal dummies for the first, second and third quarter of the year.[14]

- *TechnicalCapconstraint*: a binary variable that is one if the firm indicates that it is constrained in capacity due to constraints in technical capacities, and zero otherwise.

- *LabourCapconstraint*: a binary variable that is one if the firm indicates that it is constrained in capacity due to shortage of labour, and zero otherwise.

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[14]It has been shown in previous studies on price setting that price increases, in particular, display seasonality, see Nakamura and Steinsson (2008) and Rupprecht (2007).

- *DemandConstraint*: a binary variable that is one if the firm indicates that it is constrained in demand, and zero otherwise.

- *Time-fixed effects*: we include a dummy for each year which we do not report here.[15] We also include dummies that control for changes in VAT rates.

We employ the conditional logit model as proposed by Chamberlain (1980) to control for unobserved heterogeneity. The basic intuition is that the individual fixed effects are computed by the average number of events ($y_{it} = 1$) for a given firm.[16] The coefficient vector β is then estimated, conditional on all individual effects. This also implies that the number of observations drops in the estimations. Firms that display only price adjustments or no price adjustments in the entire sample drop out of the estimation, because these firms' contribution to the log-likelihood is zero.

5   Results

The results for the estimations with current price increases as dependent variable are reported in columns one to five of Table 1. We report marginal effects, assuming all other variables are at their sample mean and the fixed effects are at zero. Accordingly, we condition all interpretations henceforth on these assumptions, without explicitly stating them. In the first column we add only the measure for the capacity utilisation gap, the change in utilisation, the seasonal dummies and year fixed effects (which are not reported here). As noted in the previous section, the number of observations is determined by the num-

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[15]We also tested whether including a dummy for each quarter and excluding the seasonal dummies yields different results. There are substantial differences in the size of coefficients for the time dummies, which is plausible when looking at the data. However, the marginal effects of interest (the effects of constraints and the utilisation gap) are not largely different and the conclusions are still the same. We opted to report the results for estimation including the seasonal dummies plus annual fixed effects here.

[16]Full maximum likelihood would yield inconsistent estimates of β and the individual fixed effects. Chamberlain (1980) shows that this can be circumvented by conditioning on the average number of events $\overline{y}_i = \frac{1}{T_i} \sum_{t=0}^{T_i} y_{it}$.

ber of firms where we observe at least one period with a price increase and at least one period without price increase. We find, as expected, a positive and statistically significant relationship between the capacity utilisation gap and price increases. The marginal effect is 0.38. This implies that an increase in the utilisation gap from its mean by one standard deviation (0.07) increases the probability of a price change by roughly three percent. This estimate seems reasonable. The marginal effect of the change in utilisation is -0.07, implying that an increase in the utilisation rate by one percent reduces the probability of observing a price increase by 7 percent. The negative sign indicates that firms that have recently adjusted capacities are less likely to adjust prices. However, the effect is insignificant. Furthermore, seasonality plays a role for price setting. In the first quarter of the year, the probability of observing a price increase is 16 percent higher than during the last quarter of the year.

In column two, we add the two indicators for capacity constraints and the indicator for demand constraints. A capacity constraint due to restrictions in technical capacities increases the probability of observing a price increase by six percent, compared to a situation without restrictions in technical capacities. This is a significant and meaningful effect. The impact of capacity constraints due to shortages of labour has an even larger effect: compared to a situation without labour shortage, the probability of observing a price increase is ten percent higher when a firm indicates a labour supply constraint. Moreover, demand constraints have a significant effect. As expected, the sign is negative, and the marginal effect is estimated to be around -0.1. Hence, the probability of observing a price increase is about ten percent lower when faced with a demand constraint, compared to a situation without demand constraint. The marginal effect of the utilisation gap remains about the same. The change in utilisation remains insignificant. The marginal effects of the seasonal dummies remain almost identical.

In column three, we split the capacity utilisation gap and consider positive and negative

Table 1: Current price increases
Dependent variable: price increases

Capacity Utilis Gap	0.3812***	0.2479***			
	(0.0725)	(0.0788)			
% Change in Utilis	-0.0766	-0.0612	-0.0651	-0.0667	-0.0628
	(0.0584)	(0.0646)	(0.0656)	(0.0660)	(0.0660)
Winter	0.1614***	0.1552***	0.1577***	0.1585***	0.1585***
	(0.0195)	(0.0152)	(0.0155)	(0.0155)	(0.0155)
Spring	0.0069	0.0008	0.0006	0.0005	0.0008
	(0.0173)	(0.0190)	(0.0192)	(0.0193)	(0.0193)
Summer	-0.0253	-0.0349*	-0.0359*	-0.0355*	-0.0352*
	(0.0170)	(0.0205)	(0.0208)	(0.0208)	(0.0208)
TechnicalCapconstraint		0.0602**	0.0637**	0.0236	0.0621**
		(0.0267)	(0.0272)	(0.0391)	(0.0275)
LabourCapconstraint		0.1034***	0.1066***	0.1069***	0.0780***
		(0.0203)	(0.0208)	(0.0210)	(0.0285)
DemandConstraint		-0.1029***	-0.1031***	-0.1047***	-0.1044***
		(0.0204)	(0.0205)	(0.0206)	(0.0206)
Capacity Utilis Gap$^+$			0.1194	0.0519	0.0323
			(0.1301)	(0.1385)	(0.1424)
Capacity Utilis Gap$^-$			-0.4136***	-0.4318***	-0.4316***
			(0.1558)	(0.1574)	(0.1573)
Gap$^+$ * TechnConstr				0.5289	
				(0.3310)	
Gap$^+$ * LabourConstr					0.4734*
					(0.2872)
Observations	11098	11098	11098	11098	11098
Number of id	669	669	669	669	669
Pseudo R-squared	0.090	0.100	0.100	0.100	0.100
Wald p-value			0.20	0.12	0.10

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year (not reported here). Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Gap$^+$ * TechnConstr* denotes an interaction term of *Capacity Utilis Gap$^+$* and *TechnicalCapconstraint*. Analogously, *Gap$^+$ * LabourConstr* is the interaction of *Capacity Utilis Gap$^+$* and *LabourCapconstraint*. The last row provides p-values of the Wald test of the hypothesis that the absolute value of the coefficients on *Gap$^+$* and *Gap$^-$* are equal.

Table 2: Expect price increase

Dependent variable: expected price increases

Capacity Utilis Gap	0.3015***	0.1858***			
	(0.0613)	(0.0625)			
% Change in Utilis	-0.0409	-0.0208	-0.0218	-0.0218	-0.0218
	(0.0499)	(0.0506)	(0.0502)	(0.0502)	(0.0502)
Winter	-0.1882***	-0.1917***	-0.1900***	-0.1900***	-0.1899***
	(0.0107)	(0.0121)	(0.0123)	(0.0123)	(0.0123)
Spring	-0.2365***	-0.2441***	-0.2419***	-0.2420***	-0.2418***
	(0.0133)	(0.0122)	(0.0127)	(0.0127)	(0.0127)
Summer	-0.1796***	-0.1864***	-0.1849***	-0.1850***	-0.1848***
	(0.0119)	(0.0109)	(0.0111)	(0.0111)	(0.0111)
TechnicalCapconstraint		0.0365	0.0375	0.0394	0.0374
		(0.0253)	(0.0252)	(0.0332)	(0.0252)
LabourCapconstraint		0.0996***	0.0994***	0.0995***	0.0982***
		(0.0216)	(0.0216)	(0.0216)	(0.0272)
DemandConstraint		-0.0595***	-0.0586***	-0.0586***	-0.0586***
		(0.0134)	(0.0134)	(0.0134)	(0.0134)
Capacity Utilis Gap$^+$			0.1320	0.1348	0.1292
			(0.1018)	(0.1067)	(0.1089)
Capacity Utilis Gap$^-$			-0.2479**	-0.2473**	-0.2483**
			(0.1121)	(0.1123)	(0.1122)
Gap$^+$ * TechnConstr				-0.0228	
				(0.2538)	
Gap$^+$ * LabourConstr					0.0162
					(0.2232)
Observations	14213	14213	14213	14213	14213
Number of id	868	868	868	868	868
Pseudo R-squared	0.121	0.127	0.127	0.127	0.127
Wald p-value			0.44	0.39	0.43

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year. Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Capacity Utilis Gap$^+$ * TechnConstr* denotes an interaction term of *Capacity Utilis Gap$^+$* and *TechnicalCapconstraint*. Analogously, *Capacity Utilis Gap$^+$ * LabourConstr* is the interaction of *Capacity Utilis Gap$^+$* and *LabourCapconstraint*. The last row provides p-values of the Wald test of the hypothesis that the absolute value of the coefficients on *Gap$^+$* and *Gap$^-$* are equal.

utilisation gaps separately. Following the literature on convexity of the Phillips curve, we distinguish situations of excess demand (positive gap) and excess supply (negative gap) and thereby examine whether the effect of a positive gap on prices is different to the effect of a negative gap. Using this approach we allow the relationships between price increases and the capacity utilisation gap to differ, depending on the sign of the gap. This approach is commonly used in the literature to estimate a kinked Phillips curve using time series data (e.g. Laxton et al., 1999). In this paper, we produce comparable micro data estimates of the relationship between the gap and the probability of observing a price change.[17] The effects of the constraints remain almost equal to those reported in column two. A positive gap has no significant impact on the probability of observing a price increase after controlling for the presence of capacity constraints. As the correlation is positive but not too large, this result is not likely to be driven by multicollinearity. The tetrachoric correlation coefficients can be found in Table 11 in the Appendix.[18] Our assumption is, rather, that the definition of the gap measure as the deviation from the long-term average is not appropriate. We have therefore replaced the capacity utilisation gap with alternative proxies for marginal costs in the robustness section below.

The marginal effect of a negative capacity utilisation gap is -0.41, which is almost the effect that we find when we include capacity utilisation as a linear term. We also test whether the absolute values of the coefficients for Gap^+ and Gap^- are identical, the p-values for the Wald tests are reported in the last row of each Table. We cannot reject the null of equality of these coefficients. Hence, these values are not statistically different from each other. This finding suggests that we cannot reject the linearity hypothesis in the

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[17]Note that this functional form still nests the possibility that the relationship is linear, if the two slopes are identical in absolute terms. Furthermore, such an approach assumes that the break in the relationship between prices and the utilisation gap is at the utilisation gap of zero, an assumption that is rather ad hoc and not justified by any theoretical consideration, as the effect of constraints are likely to arise at situations of unusually strong excess demand.

[18]The tetrachoric correlation is used to estimate the Pearson product-moment correlation between two continuous, bivariate-normally distributed variables from dichotomized versions of those variables. See Kirk (1973).

relationship between the capacity utilisation gap and price adjustments, after controlling for constraints. However, the interaction of constraints and the size of the utilisation gap may be important here. We would therefore like to evaluate whether inflationary pressures are present when we observe constraints alone, or when we observe high levels of utilisation, or when we observe high levels of utilisation and constraints at the same time. By introducing interaction terms between the utilisation gap and the constraints, we are able to estimate whether the effect depends on the size of the utilisation gap.

In the fourth and fifth columns, we therefore include interaction terms of the size of the positive gap and the technical capacity constraints and the positive gap and the labour constraint, respectively. The interaction term between the positive gap and the technical constraint appears to be insignificant. This, however, does not necessarily mean that the interaction term is insignificant, as the usual t-test cannot be applied to interaction terms in non-linear models. Instead, the interaction effect requires computing the cross derivative of the expected value of the dependent variable. Like the marginal effect of a single variable, the magnitude of the interaction effect depends on all the covariates in the model. In addition, it can have different signs for different observations, making simple summary measures of the interaction effect difficult. In particular, the sign may be different for different values of the covariates, a fact that has been ignored by most applied researchers (Ai and Norton, 2003). As the magnitude and statistical significance of the interaction term varies by observation, we show the consistent estimates graphically in the Appendix, as proposed by Norton et al. (2004). Figure 9 illustrates the marginal effect of the interaction term in the fourth column as a function of the predicted probability of observing a price increase. The marginal effect of the interaction term in column four remains insignificant for all values, as shown in Figure 10, where we illustrate the z-statistic as a function of the predicted probability. In Figure 11 we graph the interaction terms of the positive gap and the labour constraint against the predicted probability of the dependent variable. The

Table 3: Current price decrease

Dependent variable: price decrease				
Capacity Utilis Gap	-0.7755***	-0.7342***		
	(0.0778)	(0.0741)		
% Change in Utilis	0.0988**	0.0847	0.0871	0.0865
	(0.0463)	(0.0552)	(0.0549)	(0.0538)
Winter	0.0207*	0.0289*	0.0288*	0.0280*
	(0.0124)	(0.0154)	(0.0153)	(0.0149)
Spring	-0.0007	0.0046	0.0046	0.0048
	(0.0130)	(0.0156)	(0.0155)	(0.0152)
Summer	-0.0085	-0.0071	-0.0068	-0.0066
	(0.0133)	(0.0159)	(0.0158)	(0.0155)
TechnicalCapconstraint		0.0220	0.0202	0.0216
		(0.0294)	(0.0293)	(0.0286)
LabourCapconstraint		-0.1297***	-0.1300***	-0.1277***
		(0.0289)	(0.0289)	(0.0290)
DemandConstraint		0.1320***	0.1311***	0.1536***
		(0.0143)	(0.0142)	(0.0155)
Capacity Utilis Gap$^+$			-0.6235***	-0.5614***
			(0.1356)	(0.1345)
Capacity Utilis Gap$^-$			0.8100***	1.2115***
			(0.1080)	(0.1638)
Gap$^-$ * DemandConstr				-0.5845***
				(0.1841)
Observations	12528	12528	12528	12528
Number of id	813	813	813	813
Pseudo R-squared	0.084	0.096	0.096	0.097
Wald p-value			0.34	0.11

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year. Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Capacity Utilis Gap$^-$ * DemandConstr* denotes an interaction term of *Capacity Utilis Gap$^-$* and *DemandConstraint*. The last row provides p-values of the Wald test of the hypothesis that the absolute value of the coefficients on *Gap$^+$* and *Gap$^-$* are equal.

Table 4: Expect price decrease

Dependent variable: expected price decrease				
Capacity Utilis Gap	-0.5016***	-0.4030***		
	(0.0804)	(0.0871)		
% Change in Utilis	0.0280	-0.0081	-0.0044	-0.0044
	(0.0540)	(0.0690)	(0.0686)	(0.0684)
Winter	-0.0407**	-0.0437**	-0.0437**	-0.0435**
	(0.0170)	(0.0197)	(0.0197)	(0.0196)
Spring	-0.0344**	-0.0341*	-0.0341*	-0.0339*
	(0.0161)	(0.0194)	(0.0193)	(0.0193)
Summer	0.0108	0.0184	0.0185	0.0184
	(0.0142)	(0.0182)	(0.0181)	(0.0180)
TechnicalCapconstraint		-0.0437	-0.0467	-0.0457
		(0.0394)	(0.0394)	(0.0393)
LabourCapconstraint		-0.1319***	-0.1330***	-0.1326***
		(0.0343)	(0.0344)	(0.0345)
DemandConstraint		0.1400***	0.1392***	0.1450***
		(0.0176)	(0.0175)	(0.0197)
Capacity Utilis Gap$^+$			-0.2471	-0.2312
			(0.1614)	(0.1628)
Capacity Utilis Gap$^-$			0.5138***	0.6235***
			(0.1304)	(0.2187)
Gap$^-$ * DemandConstr				-0.1474
				(0.2381)
Observations	10873	10873	10873	10873
Number of id	693	693	693	693
Pseudo R-squared	0.077	0.089	0.089	0.089
Wald p-value			0.26	0.21

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year. Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Capacity Utilis Gap$^-$ * DemandConstr* denotes an interaction term of *Capacity Utilis Gap$^-$* and *DemandConstraint*. The last row provides p-values of the Wald test of the hypothesis that the absolute value of the coefficients on *Gap$^+$* and *Gap$^-$* are equal.

interaction term varies between 0.1 and 0.45 and is significant for some observations at the ten percent significance level, as shown in Figure 12. This finding suggests that especially firms i situations where they are capacity constrained due to a shortage in labour and already run at high capacity, experience price pressure. Again, the Wald tests do not reject that the coefficients of Gap^+ and Gap^- are equal in absolute terms. This suggests that the relationship between utilisation gap and prices is not necessarily nonlinear by itself, but that the nonlinearities some researchers observe are driven by the presence of capacity constraints which, however, are not directly observable, and do not necessarily arise at very high degrees of utilisation.

In Table 2 we report the results of our estimations for expected price increases, i.e. the price increases that firms expect to conduct in the upcoming quarter. As previously, we report in the first column the marginal effects of seasonal dummies, the capacity utilisation gap and the change in capacity utilisation. The marginal effect of the capacity utilisation gap is slightly lower than we estimated for current price increases reported in Table 1. Repeating the previous example, a firm that increases the capacity utilisation rate from its mean by one standard deviation of the utilisation gap, raises the probability of expecting a price increase in the next quarter by approximately 1.8 percent. This effect is not very large. The effect of seasonal factors, though, is sizeable. Compared to the last quarter of the year, the probability of observing an expected price increase is 19, 24, and 18 percent lower in the survey periods winter, spring and summer, respectively. This is in line with the results reported in Table 1, where we find that price increases are significantly more likely during the first quarter of the year. Hence, when analysing what firms expect for the upcoming quarter, firms report their planned price increases for the first quarter of the year. Hence, it is more likely that we observe the response *"we expect to increase our price next quarter* during the fourth quarter.

In the second column, we add the constraint indicators. The constraint of technical

32

capacities is insignificant. The constraint on labour supply shows a significant marginal effect on the probability of observing an expected price increase, with a size of about 0.1. Firms that are subject to a demand constraint are estimated to have a six percent lower probability of reporting an expected price increase, compared to firms without a demand constraint.

In column three, we proceed as in the previous table and split the capacity utilisation gap into a positive and a negative gap. Our results show that again the negative gap has a significant impact and a marginal effect of -0.25, whereas the positive gap is insignificant after including the constraints. However, again we cannot reject the equality, in absolute values, of the positive and negative capacity utilisation gap coefficients in any of the estimates. The other results are largely unchanged, compared to current price increases.

The fourth column reports the model that includes an interaction term between the positive gap measure and the technical capacity constraint. Compared to the estimates in column three, the effects of constraints are almost unchanged. The marginal effect of the interaction term is illustrated in Figure 13 and the z-statistics in Figure 14 show that the marginal effects are insignificant for all observations.

In the last column we show the model including the interaction term for the positive gap measure and the labour constraint. The marginal effects are plotted in Figure 15 with the z-statistic reported in Figure 16. The latter shows that the interaction term is not significant throughout all observations.

As noted in the introduction, we also consider the effect of demand constraints on the probability of observing a price reduction. We analyse whether price reductions are as responsive to excess demand as price increases are to excess supply. Although demand constraints do not arise in the theoretical model, their empirical interpretation is important. They show how firms set prices in response to situations of excess supply and therefore have important implications for the shape of the aggregate Phillips curve. If firms reduce prices

aggressively in response to such demand constraints, the Phillips curve will be steeper in regions of excess demand (concave).

Our results for price reductions are reported in Table 3. According to the estimates shown in column one, the effect of a one standard deviation reduction in a firm's capacity utilisation gap from the mean increases the probability of observing a price reduction by about six percent. In line with previous literature, price reductions are much less seasonal than price increases (e.g. Nakamura and Steinsson, 2008, for the US and Rupprecht, 2007, for Switzerland). In the second column, we include the constraint indicators. Constraints in technical capacities are insignificant, whereas the constraint in labour supply has a marginal effect of about -0.13. Firms that experience a demand constraint have a thirteen percent higher probability of reducing prices compared to firms without a demand constraint. Splitting the capacity utilisation gap into a positive and negative gap (column three), we observe that both are significant. However, the absolute values of the marginal effects are not significantly different from each other. We interact the negative gap with the demand constraint variable in column four. The marginal effect of the interaction terms is shown in Figure 17, with the z-statistics in Figure 18. The marginal effect of the interaction term is negative throughout and significant for about half of the observations.

In Table 4 we report the model with expected price decreases as a dependent variable. In column one, we include the capacity utilisation rate linearly. The marginal effect is estimated to be -0.5. Following the previous example, this implies that a reduction of the capacity utilisation gap from the mean by one standard deviation increases the probability of expecting a price reduction by about four percent, a very similar result to that for current price reductions. In the last quarter of the year, it is significantly more likely that a firm will expect a price reduction for the next quarter, than in the first two quarters. However, the seasonal effect is relatively small compared to the seasonality in price increases. Adding the constraints in column two shows that a labour shortage reduces the probability of a

price reduction by 13 percent. A demand constraint increases the probability by 14 percent. In column three, we take account of possible non-linearity in the capacity utilisation-price relationship by including the positive and the negative utilisation gap separately. Here, only negative utilisation gaps are significantly related to price reductions, with a marginal effect of 0.51. Again, the Wald test, as described above, does not allow to reject equality of the coefficients in absolute terms. The results are almost unchanged when adding an interaction between the negative gap and the demand constraint. The marginal effect of the interaction term is insignificant for all observations (see Figures 19 and 18 for the estimated marginal effects and consistent z-statistics, respectively).

All in all, our results show that we can confirm the theoretical prediction of the capacity constraint model, which implies that capacity constraints trigger price increases. Both constraints due to the shortage of labour and constraints due to technical constraints have a positive marginal effect. We also show that price reductions are very responsive to demand constraints, a negative utilisation gap, and the interaction of the two. However, we cannot confirm that above-average capacity utilisation alone is an indicator for price pressure. This also holds true for the interaction between a capacity constraint and a positive utilisation gap. Only a utilisation gap above average and a labour supply constraint at the same time produce significant price pressure.

For the macro level, the implications of these results are twofold. First, even if utilisation rates are above average this does not yet point to significant price pressure. We find that simultaneous constraints to labour supply and positive utilisation gaps add significantly to price pressure. Furthermore, the presence of capacity and labour supply constraints alone is an indicator of inflationary pressure. Hence, it might be worth modeling such capacity constraints directly into Phillips curve relationships, in addition to an indicator for the output gap. If available, this information might lead to better and more reliable estimates empirically. Furthermore, prices are very responsive not only to capacity

constraints but also to demand constraints. We observe a strong response of price reductions to low utilisation rates and demand constraints. This would imply that the Phillips curve might even be convex-concave, rather than purely convex. Moreover, such shapes may not be detectable when employing only measures of the capacity utilisation gap as indicator in a Phillips curve estimation, as price increases react rather to constraints, which are not perfectly correlated with utilisation rates.

6   Robustness

In this section, we conduct robustness checks using different control variables than the ones we have used in the main section. Previously, we measured marginal cost as the deviation of capacity utilisation from its firm-specific average. As this measure for marginal cost is based upon utilisation, too, we use different proxies here. First, to capture marginal cost, we switch to the variables $E(Increasecost)$ and $E(Decreasecost)$. Firms are asked in the survey whether the cost for input products and raw materials have changed, and whether they have increased or decreased. This may also yield a good proxy for marginal cost. Unfortunately, wages or changes in wages are not covered in the survey. Second, we include a proxy for competition. Firms are asked whether their competitive position in the Swiss market has increased, decreased or remained unchanged. Thus, we construct a binary variable that is equal to one (*Competitive Position$^+$=1*) if the competitive position has improved and zero otherwise. *Competitive Position$^-$* is equal to one if the competitive position has worsened and zero otherwise. It should be noted that these variables are crude proxies for marginal costs or competition, and far from being perfect. However, they are the best measures that are available on the micro level. Interestingly, the results for our main variables of interest, the constraints, remain robust and the sizes of the marginal effects are mostly in line with the ones reported in the main section. Table 5 presents

the results for price increases in the quarter under review. The first column shows the results for the regression, including only the change in costs, the seasonal terms and the time dummies. The second column adds the constraints. The third column reports results for the model, including the costs, constraints and the proxies for competitive position. As can be seen, the presence of a technical capacity constraint increases the probability of observing a price increase in the current quarter by about five percent. In the main section, this estimate was marginally higher, at around six percent. The effects of the labour constraint (around 10 percent) and the demand constraint (around -10 percent) are also very close to the estimates in the main section, and the signs of the controls are as expected. An expected increase in costs increases the probability of observing a price increase by about 10 percent, an improvement in competitive position by about six percent. The effect of the expected increase in costs appears relatively low. However, the survey asks about an expected increase in cost in the upcoming quarter. If firms pass through costs to prices only at the time costs change, this effect should become larger in the upcoming quarter.[19]

Table 6 reports the results for expected price increases in the upcoming quarter. In these regressions, the marginal effect of a rise in expected cost becomes much larger. An increase in expected cost increases the probability of observing a price change by around 50 percent. Again, technical capacity constraints are insignificant after including all control variables, comparable to the results in the main part. The presence of labour constraints increases the probability of observing a price change by around 8 percent.

Tables 7 and 8 report the results for current and upcoming price decreases, respectively. Analogously to the previous tables, the results for the main variables of interest are almost unchanged. Interestingly, a worsening of the competitive position is associated with a

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[19]There is evidence that firms in Switzerland pass through changes in value added taxes (which are known to them well in advance) only at the time these changes become effective (Kaufmann, 2008). Thus, it seems that firms do not adjust their prices in advance. This is also what we find in this paper.

substantially higher probability of reducing prices. The marginal effect is around 0.27 for both current and expected price reductions.

Summing up, the results presented in the previous section are robust to the inclusion of alternative control variables; both size and significance of the marginal effects of the constraints are almost unchanged.

Table 5: Current price increases with alternative controls
Dependent variable: price increases

E(Increase cost)	0.1103***	0.1061***	0.0965***
	(0.0150)	(0.0149)	(0.0120)
E(Decrease cost)	-0.0644**	-0.0506*	-0.0519
	(0.0268)	(0.0278)	(0.0326)
TechnicalCapconstraint		0.0540**	0.0472**
		(0.0259)	(0.0214)
LabourCapconstraint		0.1140***	0.0922***
		(0.0231)	(0.0169)
DemandConstraint		-0.0984***	-0.0923***
		(0.0146)	(0.0173)
Competitive Position$^+$			0.0576***
			(0.0150)
Competitive Position$^-$			-0.0341
			(0.0262)
Winter	0.1624***	0.1648***	0.1409***
	(0.0176)	(0.0178)	(0.0117)
Spring	0.0210	0.0143	0.0123
	(0.0170)	(0.0169)	(0.0158)
Summer	-0.0270*	-0.0322**	-0.0317*
	(0.0163)	(0.0162)	(0.0176)
Observations	14092	14092	14092
Number of id	793	793	793
Pseudo R-squared	0.0907	0.102	0.104

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year (not reported here). Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Competitive Position*$^+$ is equal to one if a firm indicates that its current competitive position in Switzerland has improved, i.e. the competitive pressure from other firms is *lower*. Analogously, if a firm indicates its current competitive position in Switzerland has worsened (*Competitive Position*$^-$ = 1) then the competitive pressure from other firms is *higher*.

Table 6: Expected price increases with alternative controls
Dependent variable: expected price increases

E(Increase cost)	0.5196***	0.5170***	0.4652***
	(0.0111)	(0.0112)	(0.0170)
E(Decrease cost)	-0.1643***	-0.1563***	-0.1524***
	(0.0428)	(0.0433)	(0.0462)
TechnicalCapconstraint		0.0437*	0.0384
		(0.0262)	(0.0238)
LabourCapconstraint		0.0865***	0.0753***
		(0.0211)	(0.0188)
DemandConstraint		-0.0717***	-0.0591***
		(0.0161)	(0.0160)
Competitive Position$^+$			0.0624***
			(0.0164)
Competitive Position$^-$			-0.0594**
			(0.0255)
Winter	-0.2195***	-0.2176***	-0.2128***
	(0.0145)	(0.0146)	(0.0165)
Spring	-0.2510***	-0.2569***	-0.2564***
	(0.0154)	(0.0154)	(0.0176)
Summer	-0.2004***	-0.2054***	-0.2008***
	(0.0151)	(0.0151)	(0.0168)
Observations	17709	17709	17709
Number of id	1010	1010	1010
Pseudo R-squared	0.297	0.301	0.302

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year (not reported here). Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Competitive Position*$^+$ is equal to one if a firm indicates that its current competitive position in Switzerland has improved, i.e. the competitive pressure from other firms is *lower*. Analogously, if a firm indicates its current competitive position in Switzerland has worsened (*Competitive Position*$^-$ = 1) then the competitive pressure from other firms is *higher*.

Table 7: Current price decreases with alternative controls

Dependent variable: price decreases

E(Increase cost)	-0.0263**	-0.0187*	-0.0273**
	(0.0105)	(0.0101)	(0.0139)
E(Decrease cost)	0.1425***	0.1291***	0.2140***
	(0.0134)	(0.0129)	(0.0186)
TechnicalCapconstraint		-0.0245	-0.0393
		(0.0202)	(0.0273)
LabourCapconstraint		-0.0986***	-0.1108***
		(0.0219)	(0.0237)
DemandConstraint		0.1345***	0.1712***
		(0.0122)	(0.0138)
Competitive Position$^+$			-0.0459**
			(0.0198)
Competitive Position$^-$			0.2811***
			(0.0142)
Winter	0.0521***	0.0508***	0.0740***
	(0.0092)	(0.0089)	(0.0146)
Spring	0.0057	0.0095	0.0135
	(0.0108)	(0.0103)	(0.0155)
Summer	-0.0032	-0.0004	-0.0058
	(0.0110)	(0.0106)	(0.0155)
Observations	16432	16432	16432
Number of id	990	990	990
Pseudo R-squared	0.0692	0.0929	0.120

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year (not reported here). Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Competitive Position$^+$* is equal to one if a firm indicates that its current competitive position in Switzerland has improved, i.e. the competitive pressure from other firms is *lower*. Analogously, if a firm indicates its current competitive position in Switzerland has worsened (*Competitive Position$^-$* = 1) then the competitive pressure from other firms is *higher*.

Table 8: Expected price decreases with alternative controls
Dependent variable: expected price decreases

E(Increase cost)	-0.0654***	-0.0564***	-0.0770***
	(0.0160)	(0.0154)	(0.0175)
E(Decrease cost)	0.2586***	0.2449***	0.4850***
	(0.0280)	(0.0276)	(0.0164)
TechnicalCapconstraint		-0.0361	-0.0465
		(0.0287)	(0.0353)
LabourCapconstraint		-0.1180***	-0.1231***
		(0.0306)	(0.0297)
DemandConstraint		0.1299***	0.1525***
		(0.0154)	(0.0177)
Competitive Position^{+}			-0.0830***
			(0.0254)
Competitive Position^{-}			0.2672***
			(0.0177)
Winter	-0.0026	-0.0000	-0.0074
	(0.0137)	(0.0132)	(0.0181)
Spring	-0.0327**	-0.0265*	-0.0422**
	(0.0154)	(0.0149)	(0.0187)
Summer	0.0177	0.0197	0.0191
	(0.0132)	(0.0128)	(0.0184)
Observations	13986	13986	13986
Number of id	819	819	819
Pseudo R-squared	0.168	0.186	0.210

Robust standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. The conditional logit is estimated using time dummies for every year (not reported here). Marginal effects are reported holding all other variables at the sample mean. The marginal effect of binary variables is the marginal effect for a discrete change from zero to one. *Competitive Position*$^{+}$ is equal to one if a firm indicates that its current competitive position in Switzerland has improved, i.e. the competitive pressure from other firms is *lower*. Analogously, if a firm indicates its current competitive position in Switzerland has worsened (*Competitive Position*$^{-}$ = 1) then the competitive pressure from other firms is *higher*.

7 Conclusions

This paper investigates the role of capacity utilisation and capacity constraints for the price-setting behaviour of firms. We show in a theoretical model that capacity constraints at the firm level enter into the price-setting decision, making prices dependent on marginal cost and a measure of the distribution of firms in the economy that are faced with capacity constraints. Using a unique panel dataset of quarterly data of manufacturing firm business tendency surveys from 1999-2007 for Switzerland, we empirically analyse the role of different capacity constraints for the pricing behaviour of firms. We find that, as expected, firms with a high level of capacity utilisation are generally more likely to increase and less likely to decrease prices. We conclude that the relationship between capacity utilisation and prices confirms the prediction of the theoretical model: when firms are faced with capacity constraints, they are more likely to raise prices. We furthermore find that price reductions are very responsive to reductions in capacity utilisation rates and demand constraints. Our results therefore suggest that, at the macro level, inflation accelerates more quickly during periods of substantial excess demand but also decline quickly during periods of substantial excess supply. This has important policy implications at the macro level. Some researchers have argued that capacity constraints at high levels of the output gap make it more costly in terms of output to bring inflation down once it has been relatively high. If this were the case, optimal monetary policy rules would suggest that central banks should raise interest rates more aggressively in response to an increase in the output gap and cut rates less severely when they are faced with a reduction of the output gap (Schaling, 2004). The strong responsiveness of price reductions, however, suggests that the output that has to be sacrificed to reduce inflation is not that large, as firms are not reluctant to reduce prices in the face of demand constraints. Our results are robust to the inclusion of proxies for changes in costs and the competitive position of firms.

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Appendix

First Order Condition for Final Goods Producers

First order conditions for optimisation program of final goods producers is given by

$$\max_{Y_{j,t}} \mathbf{P}_t[\int_0^1 Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} dj]^{\frac{\epsilon}{\epsilon-1}} - \int_0^1 P_{j,t} Y_{j,t} dj, \tag{24}$$

Hence, the first order condition when the constraint is non-binding is

$$\frac{\partial}{\partial Y_{j,t}} = \mathbf{P}_t[Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} dj]^{\frac{1}{\epsilon-1}} Y_{j,t}^{-\frac{1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} - P_{j,t} = 0 \tag{25}$$

$$\Leftrightarrow \mathbf{P}_t[Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} dj]^{\frac{1}{\epsilon-1}} Y_{j,t}^{-\frac{1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} - P_{j,t} = 0 \tag{26}$$

Rearranging yields

$$\Leftrightarrow [Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} \nu_{j,t}^{\frac{1}{\epsilon}} dj]^{\frac{\epsilon}{\epsilon-1}} Y_{j,t}^{-1} \nu_{j,t} = (\frac{P_{j,t}}{\mathbf{P}_t})^{\epsilon} \tag{27}$$

and substituting equation (1) into the previous equation yields

$$\Leftrightarrow Y_t Y_{j,t}^{-1} \nu_{j,t} = (\frac{P_{j,t}}{\mathbf{P}_t})^{\epsilon} \tag{28}$$

which finally yields the first order condition for the case where the constraint is non-binding $\nu_{j,t} \leq \tilde{\nu}_{j,t}$

$$\Leftrightarrow Y_{j,t} = Y_t \nu_{j,t} (\frac{P_{j,t}}{\mathbf{P}_t})^{-\epsilon}. \tag{29}$$

In case the constraint is binding, demand for intermediate good j simply equals the maximum supply (see equation (3) in the main part).

First Order Condition for Intermediate Goods Producers

First order condition for intermediate goods producers who reoptimize in period t:

Optimisation problem:

$$\max_{P_t^*} \sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\Delta_{t+k} E_\nu\{Y_{t+k}^{int}\}[P_t^* - MC_{t+k}]\} \tag{30}$$

subject to

$$E_\nu\{Y_{t+k}^{int}\} = (\frac{P_t^*}{\mathbf{P}_{t+k}})^{-\epsilon} Y_{t+k} \int_0^{\widetilde{\nu}_{t+k}^t} \nu dF(\nu) + \overline{Y_t} \int_{\widetilde{\nu}_{t+k}^t}^{\infty} dF(\nu). \tag{31}$$

The first order condition is

$$\sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\Delta_{t+k} E_\nu\{Y_{t+k}^{int}\}\} + \sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\Delta_{t+k} \frac{\partial[E_\nu\{Y_{t+k}^{int}\}]}{\partial P_t^*}[P_t^* - MC_{t+k}]\} = 0 \tag{32}$$

where

$$\frac{\partial[E_\nu\{Y_{t+k}^{int}\}]}{\partial P_t^*} = -\epsilon(\frac{P_t^*}{\mathbf{P}_{t+k}})^{-\epsilon} \frac{1}{P_t^*} Y_{t+k}^{int} \int_0^{\widetilde{\nu}_{t+k}^t} \nu dF(\nu). \tag{33}$$

Substituting equation (33) into equation (32) and making some rearrangements yields

$$\sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\Delta_{t+k} E_\nu\{Y_{t+k}^{int}\}\} = \epsilon \sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\Delta_{t+k} (\frac{P_t^*}{\mathbf{P}_{t+k}})^{-\epsilon} \frac{Y_{t+k}^{int}}{P_t^*} \int_0^{\widetilde{\nu}_{t+k}^t} \nu dF(\nu)[P_t^* - MC_{t+k}]\}. \tag{34}$$

We now write (34) in terms of the share of firms that are capacity constrained $\Gamma(\widetilde{\nu}_{t+k}^t)$

$$P_t^* = \frac{E_t \sum_{k=0}^{\infty} (\beta\theta)^k \Delta_{t+k} E_\nu\{Y_{t+k}^{int}\} MC_{t+k} \epsilon \Gamma(\widetilde{\nu}_{t+k}^t)}{E_t \sum_{k=0}^{\infty} (\beta\theta)^k \Delta_{t+k} E_\nu\{Y_{t+k}^{int}\}[\epsilon \Gamma(\widetilde{\nu}_{t+k}^t) - 1]} \tag{35}$$

which is equivalent to equation (8) in the main part.

Data Sources, Statistics and Interaction Terms

Table 9: Data description

Variable	Availability	Description
		Source: KOF quarterly manufacturing business tendency survey
Selling Price	1984-2007	The price of the firm's main product has increased (+1), decreased (-1) or remained unchanged (0) in the last three months.
E(Selling Price)	1984-2007	The firm expects to rise (+1), decrease (-1) or leave unchanged (0) its selling price in the coming three months.
Capacity Utilisation	1984-2007	Quantitative response of the firm indicating its capacity utilisation in production from 50 to 100 % in the last three months
TechnicalCapconstraint	1999-2007	Firms currently are restricted in technical capacity, yes (1) or no (0)
LabourCapconstraint	1999-2007	Firms currently are restricted in labour supply, yes (1) or no (0)
DemandConstraint	1999-2007	Firms currently are restricted in demand for their product, yes (1) or no (0)
E(Change in Cost)	1999-2007	The firm expects that prices for their input products and raw materials to rise (+1), decline (-1) or remain unchanged (0). in the coming three months.
Competitive Position	1999-2007	The competitive position within the Swiss market has improved (+1), worsened (-1) or remained unchanged (0).

Table 10: Summary statistics estimation sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Capacity utilisation	25608	81.949	13.119	50	110
Gap	25608	0	0.105	-0.462	0.69
Change in cap utilis	20883	0.009	0.119	-0.545	1.20
DemandConstraint	25608	0.419	0.493	0	1
TechnicalCapconstraint	25608	0.055	0.228	0	1
LabourCapconstraint	25608	0.088	0.283	0	1
Price increase exp	25608	0.140	0.347	0	1
Price decrease exp	25608	0.099	0.299	0	1
Price increased	25608	0.088	0.283	0	1
Price decreased	25608	0.158	0.365	0	1
E(Increase cost)	25608	0.300	0.458	0	1
E(Decrease cost)	25608	0.048	0.214	0	1
Competitive Position^{+}	25608	0.120	0.325	0	1
Competitive Position^{-}	25608	0.095	0.293	0	1

Table 11: Tetrachoric correlations

|	Positive Gap	Negative Gap	DemandConstr	TechnConstr	LabourConstr
Positive Gap	1.00				
Negative Gap	-1.00	1.00			
DemandConstr	-0.36	0.38	1.00		
TechnConstr	0.24	-0.25	-0.36	1.00	
LabourConstr	0.21	-0.23	-0.45	0.35	1.00
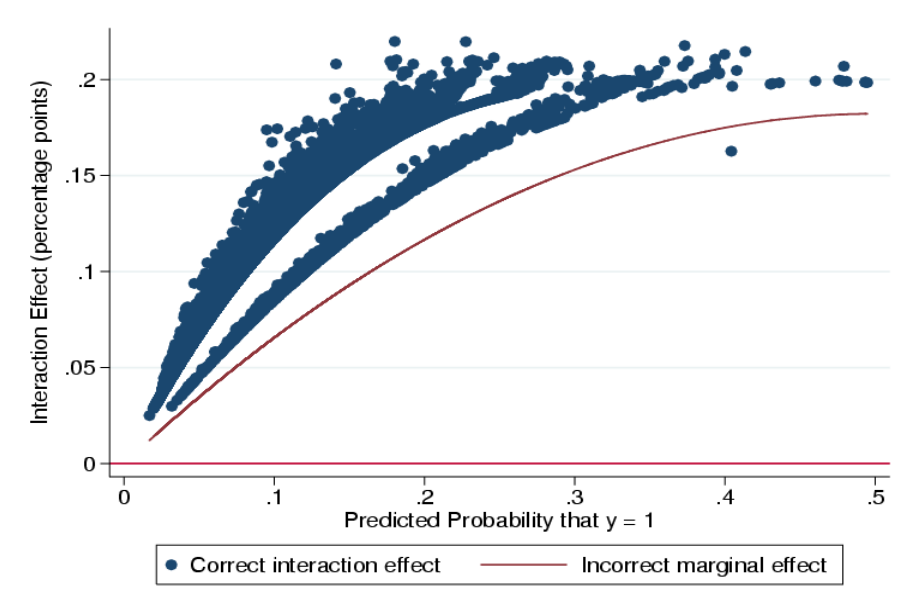
Figure 9: Marginal effects of the interaction term Gap^+ and $TechnicalCapconstraint$
The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: current price increase.
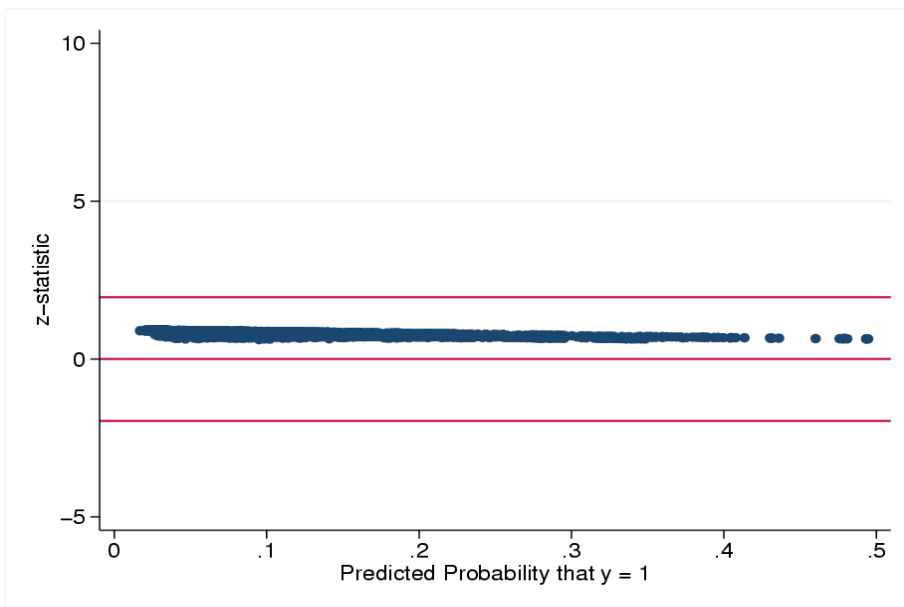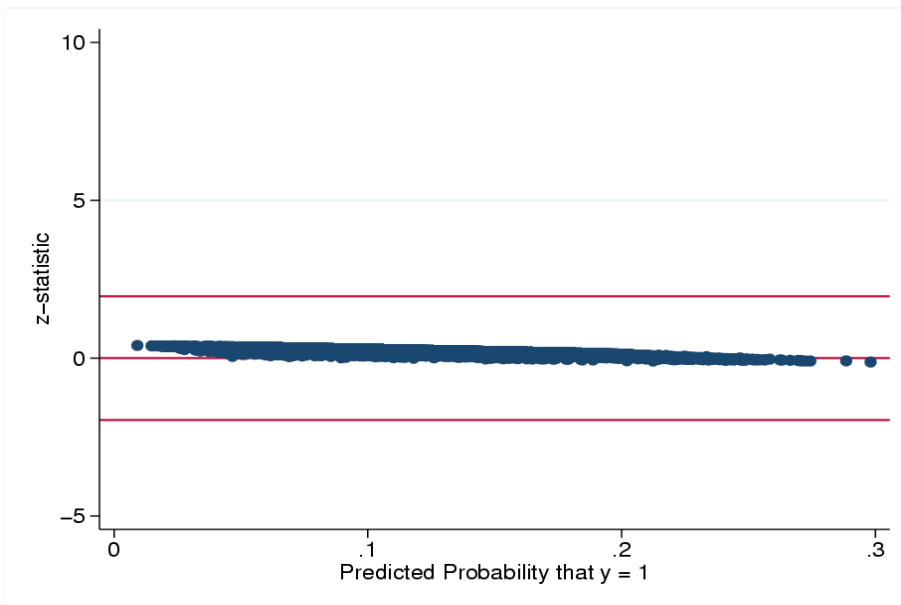

Figure 10: Consistent z-statistic of marginal effect of the interaction term Gap^+ and $TechnicalCapconstraint$
The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: current price increase.
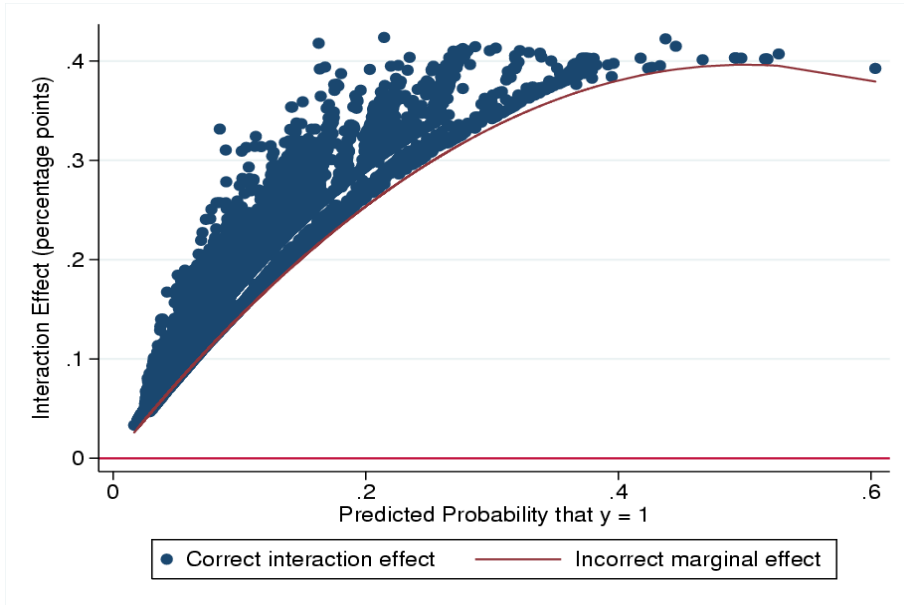
Figure 11: Marginal effects of the interaction term Gap^+ and $LabourCapconstraint$

The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: current price increase.
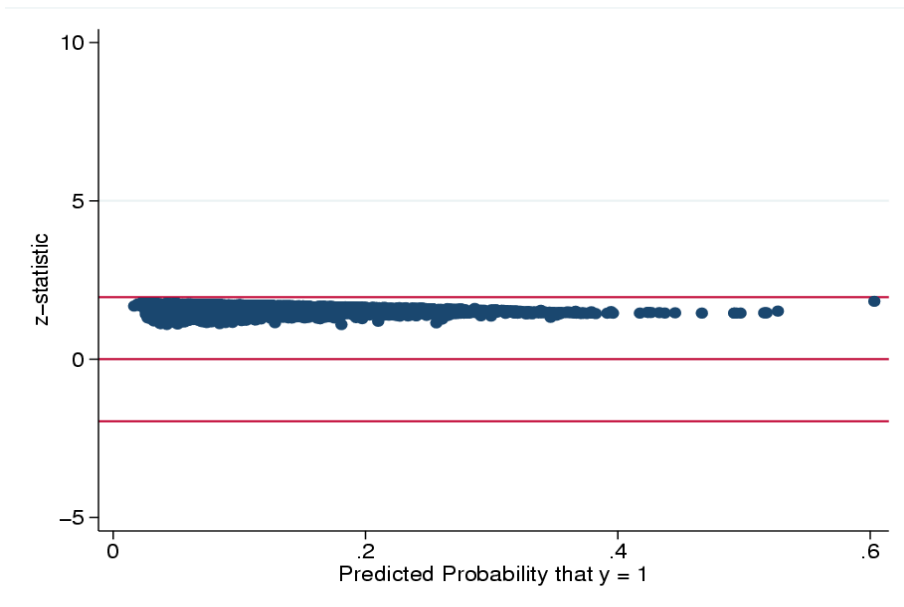
Figure 12: Consistent z-statistic of marginal effect of the interaction term Gap^+ and $LabourCapconstraint$

The consistent z-statistic is the dotted series (one dot for each observation) and the inconsistent z-statistic, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: current price increase.
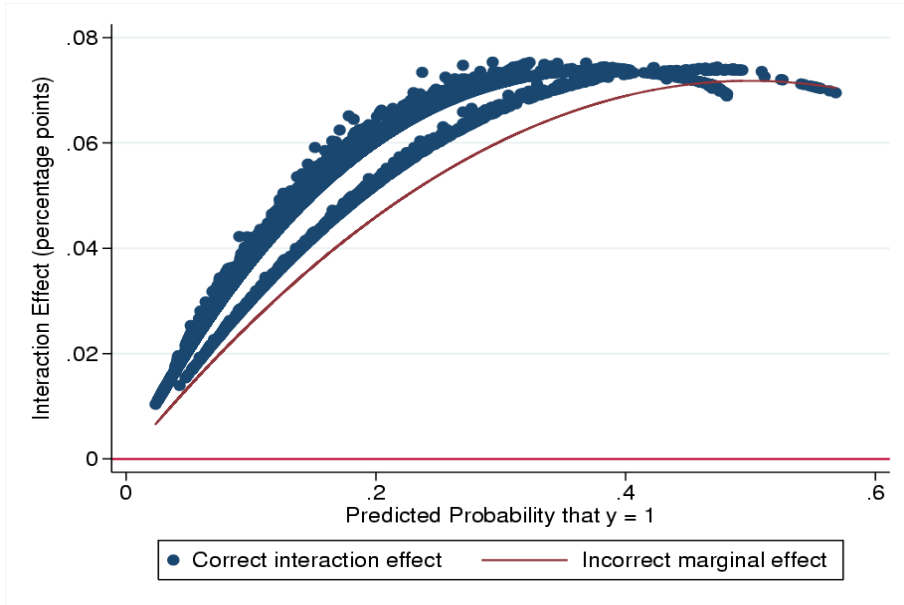
Figure 13: Marginal effects of the interaction term Gap^+ and $TechnicalCapconstraint$

The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: expected price increase.
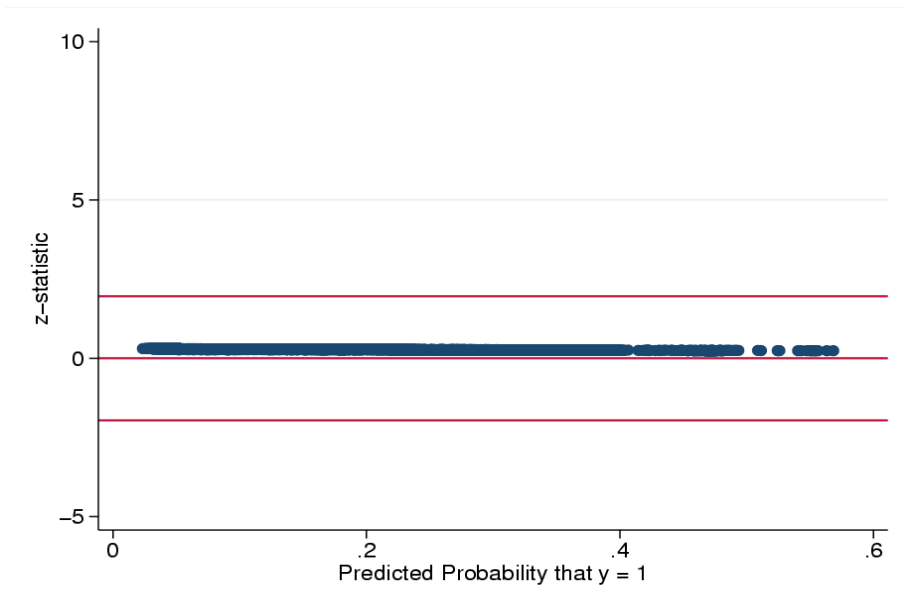
Figure 14: Consistent z-statistic of marginal effect of the interaction term Gap^+ and $TechnicalCapconstraint$

The consistent z-statistic is the dotted series (one dot for each observation) and the inconsistent z-statistic, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: expected price increase.
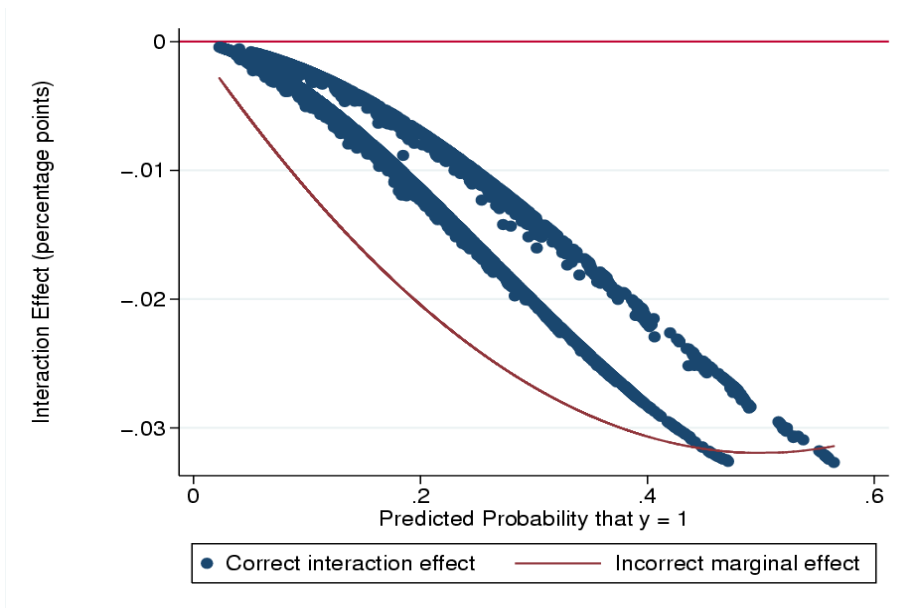
Figure 15: Marginal effects of the interaction term Gap^+ and $LabourCapconstraint$

The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: expected price increase.
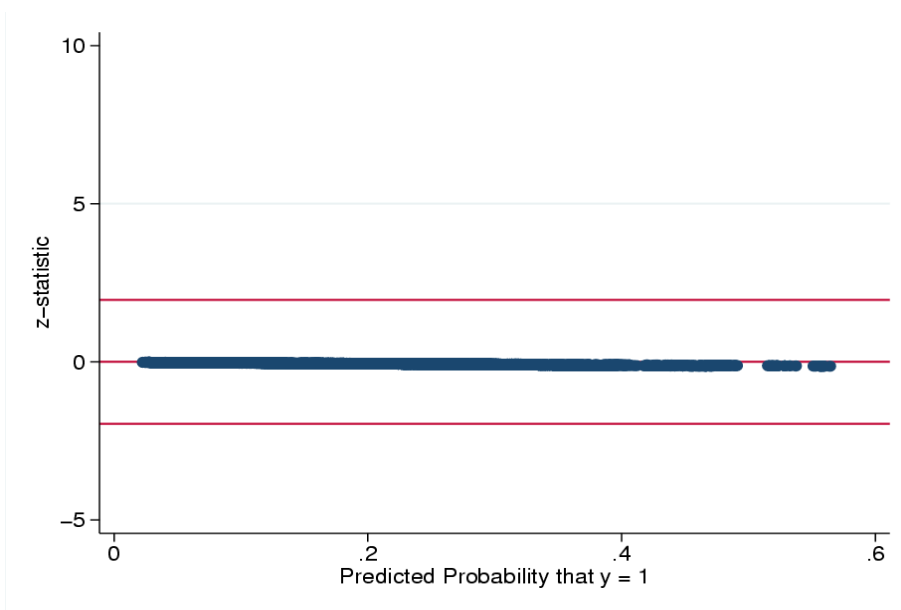
Figure 16: Consistent z-statistic of marginal effect of the interaction term Gap^+ and $LabourCapconstraint$

The consistent z-statistic is the dotted series (one dot for each observation) and the inconsistent z-statistic, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: expected price increase.

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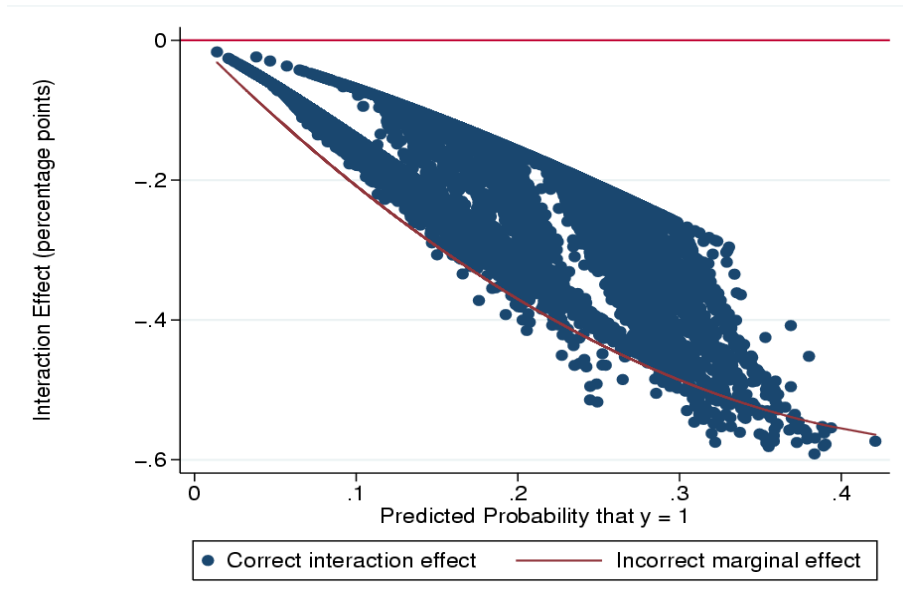
Figure 17: Marginal effects of the interaction term Gap^- and $DemandConstraint$

The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: current price decrease.
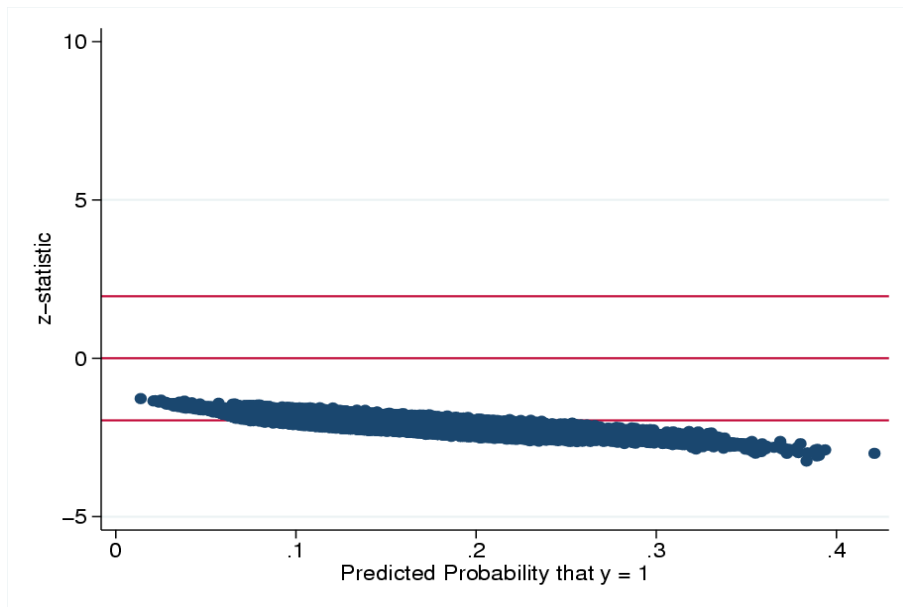
Figure 18: Consistent z-statistic of marginal effect of the interaction term Gap^- and $DemandConstraint$

The consistent z-statistic is the dotted series (one dot for each observation) and the inconsistent z-statistic, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: current price decrease.
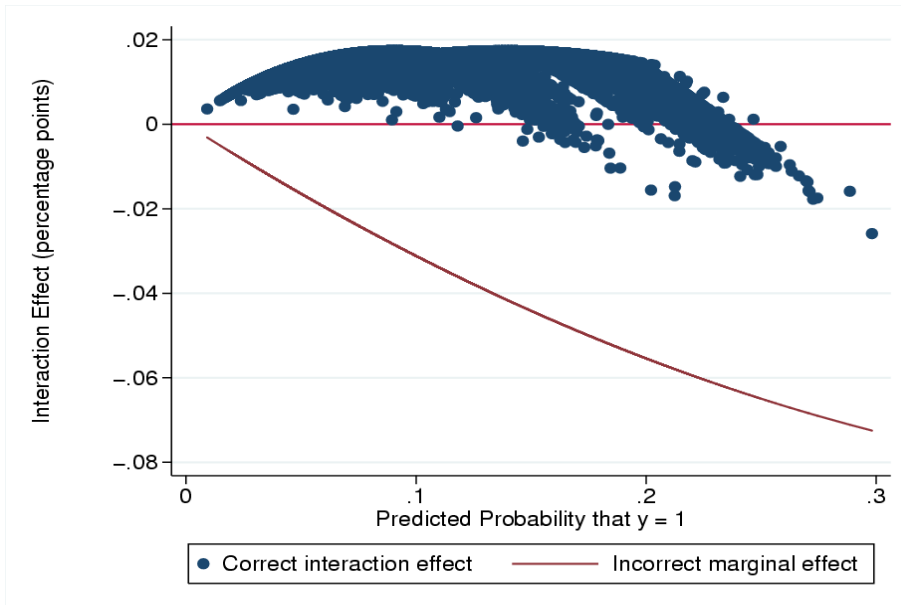
Figure 19: Marginal effects of the interaction term Gap^- and $DemandConstraint$

The marginal effect is the dotted series (one dot for each observation and the incorrectly estimated marginal effect, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: expected price decrease.

Figure 20: Consistent z-statistic of marginal effect of the interaction term Gap^- and $DemandConstraint$

The consistent z-statistic is the dotted series (one dot for each observation) and the inconsistent z-statistic, that ignores cross derivatives (line), as a function of predicted probability. Dependent variable: expected price decrease.

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