Norwegian School of Economics
Bergen, December 2013

# Linking Price Setting Behaviour with Lumpy Factor Adjustments

A micro panel data analysis of Norwegian manufacturing firms

Halvorsen, Sandra Kristine

Refnin, Eyolf

Supervisor: Øivind Anti Nilsen

Master thesis in financial economics

NORWEGIAN SCHOOL OF ECONOMICS

# Abstract

This paper takes a descriptive approach to investigate the interrelation between price changes and factor demand based on the observation of rigidness in prices and lumpy adjustments of capital and labour stock. Based on empirical research, the assumptions that firms use mark-up pricing and compete in monopolistic markets, give reason to believe that firms will adjust their prices more than normally during episodes of large factor adjustments. Using micro panel data on Norwegian manufacture industries (VPPI), we find such a relationship to be weak or non-existing. The effect on price changes from labour adjustments are more present than from investments in capital. The results suggests that firms are operating in competitive markets where the prices are more dependent on other factors, such as their market share, than their cost of input factors.

# Table of Contents

# 1. Introduction

## 1.1 Background and motivation

Most central banks today agree that the monetary policy must aim to stabilize the inflation in a country. Many macro models of inflation are often dependent on highly stylized assumptions on for instance firms' price setting behaviour[1]. Evidence from microeconomic research is therefore crucial in building macro models as this ensures internal consistency. Studies show that price setting behaviour exhibit rigidities that prevent prices to be fully flexible to continuous optimization[2]. The presence of nominal rigidities implies that firms' nominal price setting behaviour affects real variables, meaning that we have monetary non-neutrality in the short run (Anglioni et al., 2006). This has important implications for the monetary transmission mechanism in addition to welfare consequences of business cycles, and real exchange rates (Nakamura and Steinsson, 2008). In addition, the speed of adjustment of inflation in the economy to shocks is directly linked to the speed of price adjustment of individual firms (Álvarez et al., 2006). A substantial body of economic research on the dynamics of individual firm's price setting attempts to acquire better understanding of the nature of price adjustments, in order to create better macro models for monetary policy that reflect realistic economic dynamics.

The textbook representation of price adjustments is that prices primarily react to demand. This however, is hard to find support for with empirical evidence (ref. Bucht 1997, Lundin et al., 2009). Bucht (1997) presents a market model with rigid prices where firms must choose between customer stock (market share) and capital stock. In other words, there is a trade-off when firms set their prices in accordance to their marginal costs and mark-ups, and their market share. Prices in rigid price models respond to changes in marginal costs just as they would in a fully flexible price model, however prices will not adjust to small movements in

---

[1] N.Gregory Mankiw (1985): "In neoclassical models prices are fully flexible. They represent the continuous of economic agents and the continuous intersection of supply and demand. In Keynesian models, prices are often assumed to be sticky."

[2] See Nakamura and Steinsson (2013) "Price Rigidity: Microeconomic Evidence and Macroeconomic Implications"

marginal costs. This implies that changes in marginal costs will not fully justify the price changes.

In the context of New-Keynesian monetary theory, investments are assumed to be convex. It is widely accepted, however, that firms typically invest in a lumpy nature. The lumpy nature suggests non-convexities in capital adjustment costs, and that capital and labour adjustment are precluded with fixed costs, irreversibility or indivisibilities (Nilsen et al., 2009). This has great implications for the exercising of the monetary policy and its effects on the economy. According to Reiter et al. (2012), in a model with lumpy investments and sticky prices, monetary shocks lead to large but short-lived impacts on output and inflation. The reason behind this result is that non-convex adjustment costs conceal a realistic interest rate sensitivity of investments. Investigating the lumpy investments' effect on prices are therefore interesting to conduct as this clearly has an important role in the monetary transmission mechanism. Estimates from price equations of this type typically show that prices respond to factor prices such as materials and wages (Bils and Chang, 2000) and investments in capital (Lundin et al., 2009).

This paper will take a descriptive and non-parametric approach on describing the nature of price setting behaviour, investments in capital and labour, and to see the relationship between these. By using micro data from the Norwegian manufacture industries (VPPI) from 2002-2009, we have a broad dataset of price quotes and investment behaviour of different product- and industry sectors over several years. More precisely, our research question is formulated as follows:

*How are price changes interrelated with lumpy adjustments in capital and labour?*

The objective of the paper is to investigate firms' price and factor adjustment behaviour, and their relationship both *within* and *across* different producers. The first will help us understand the dynamics of firms' factor and price adjustment. The latter will help us to get a better understanding of the differences in the idiosyncratic characteristics of firms and how this effect the price and factor adjustment behaviour. By expanding our knowledge in price setting behaviour, the results can ultimately be used to improve the currently used models of monetary transmission mechanism. The goal is not simply to show whether factor and price adjustments are lumpy or not, but to investigate how the relationship between them is characterised in different product groups and industries.

The following section will include a presentation of earlier work on the subject. Section three introduces the theoretical background of price setting behaviour and the lumpy nature of investment in capital and labour stock adjustment. The next section will presents the panel data set with descriptive data. Section five introduces the method of the empirical analysis. This is followed by section six, which presents the empirical results of our investigation. In section seven we use the different definitions of spikes to further study the interrelation between the factor adjustments. Section eight concludes.

# 2. Empirical Reseach

Access to wide panel data on firms' price setting and investment behaviour has only existed in the later years in most countries. Empirical research is therefore focused on US or Western Europe data. Studies on firms' price setting behaviour have been conducted both quantitative and qualitative. As a quantitative approach, investigations of micro data using consumer price index (CPI) and/or producer price index (PPI) are widely used. Papers using this method to formulate stylized facts or models on price setting are vast in number and only a few will be mentioned here. Álvarez et al., (2006) use CPI and PPI from the euro area and find that price setting behaviour is heterogeneous and asymmetric, that there is a slightly downward price rigidity, and that prices are more rigid in the euro area than in the US. They also find that implicit and explicit contracts, and coordination failure theories are important for explaining the rigidities, whereas menu costs are not considered very important. These theories will be described closer in section 3. Later papers confirm these results with small variations, such as in Baudry et al. (2007) on French CPI data, Klenow and Kryvtsow (2008) and Nakamura and Steinsson (2008) on CPI from the US. Baudry et al. (2007) find that average price changes are large (around 10%), but small price changes are not unusual. There is strong heterogeneity across sectors, and prices are subject to significant shocks (such as the euro changeover), and seasonality. In addition, both fluctuations in size of price changes and the share of price decreases have a substantial impact on aggregate level.

Studies based on surveys give a qualitative approach to the subject. Here the respondents are asked directly about their motives with regards to price setting. In the US, Blinder (1991, 1995) and Blinder et al. (1998) surveyed about 200 companies, Hall et al. (2000) use UK data on 654 establishments and Apel et al. (2001) on 600 Swedish firms. The three studies suggest that prices are indeed rigid, although the estimated frequency of price change differs somewhat. The rigidity is mainly driven by costumer relationships – implicit and explicit contracts. It seems that more US firms use a time-dependent pricing model where the price adjustments decision is set to fixed points in time or according to a stochastic process independent of time. The UK and Swedish price setters are more state-dependent where the price adjustments are a function of the state of the economy; these models will be described in section 3. Fabiani et al. (2005) investigate pricing behaviour of a large survey set of firms in the euro area. They show that firms operate in monopolistic markets where prices most commonly follow mark-up rules, where the chosen price is a function of the marginal costs and an additional constant percentage of profit. They also find price rigidness that can be explained by customer relationships and coordination failure. Moreover, they argue that firms adjust prices asymmetrically depending on the type of shock: price increases are mostly motivated by cost shocks and price decreases are mostly motivated by reduction in demand.

Qualitative data are very useful as they can shed light on certain aspects of price adjustment motives that can be further investigated. Surveys are therefore used as complementary to empirical analysis and can give insights to the relative importance of nominal versus real rigidities, or the type of information the price setter uses to revise their prices. They can also be used in crosschecking results obtained through empirical analysis on quantitative data (Álvarez et al., 2006).

If we believe most firms use a mark-up price setting rule (Fabiani et al., 2005), it is natural to investigate the relationship between firms' costs and pricing. Lundin et al. (2009) formulate a model of a firm in a competing market who makes investments in physical capital. They find that investments have a strong relationship to prices. Their model also reveals that prices depend on costs and competitors' prices, and are weakly related to shocks in demand. In another study, Bils and Chang (1999) distinguish between cost increases due to factors (materials, wages etc.) and increases in marginal costs due to investments. They find that prices respond more to increases in costs driven by factor prices than to increases in marginal costs due to expansions in output (investments). They also find that prices respond considerably more to cost increases in materials and energy than the cost increases due to wages or reduction in productivity. This seemingly weak relationship between adjustments in labour (or changes is wages) and price is also emphasised in a paper by Carlsson and Skans (2012). They explain that a possible reason for this could be explained by a pricing equation where the price set today (when changing the price) is a discounted sum of today's and expected future marginal costs, such as Calvo (1983) suggested in his paper on rigid pricing. Furthermore, they discuss whether a sticky information model, first suggested by Mankiw and Reis (2002), may explain the weak relationship between changes in wages and prices where prices are not sticky, but information is. An alternation of the sticky information model, but with nominal rigidities supplemented to the model, suits the data well.

While Carlsson and Skans (2012) confirm the time-dependent price setting model by Calvo (1983) using Swedish industry micro data, Bratlie (2013) in his thesis rejects the model. He uses the same dataset as we have in our paper and develop a series of stylized facts about price adjustments in Norwegian manufacturing industries. He finds declining hazard rates as a function of the price durations, which means that the longer it has been since the last price change, the lower is the probability that the price will change. This is not in accordance with most macro models where constant hazard rates are assumed, and it highlights the importance of studies on price adjustments, because current macro models may not be optimal to observed dynamics in the economy. Asphjell (2013) studies the cost of adjustments (menu costs) as a possible source for price rigidities using the same dataset. He finds that fixed costs of adjustment are present and that plant values could increase by as much as 2 %, as opposed to a situation where such costs where absent. This result challenges earlier results on the importance of menu costs, which states that menu costs have little importance for price adjustment decisions (e.g. Álvarez et al., 2006)

Building on Sheshinski and Weiss (1977), Golosov and Lucas (2003), develop a (S, s) model in which firms are subject to idiosyncratic productivity shocks and general inflation. They find that switching from time-dependent pricing models to state-dependent models substantially reduces price stickiness. The model shows that idiosyncratic shocks account for most of the price adjustment in the U.S, which means that a state-dependent price setting model is used. Their results contradict other studies mentioned above, such as Hall et al., (2000) and Apel et al. (2001). Along the same line, Johnston (2009) and Reiter et al. (forthcoming) investigate generalized (S, s) models on pricing and investment decisions in equilibrium calibrated to micro panel data. Johnston (2009) finds that the presence of lumpy investments lowers the impact of monetary disturbances. On the other hand, Reiter et al. (forthcoming) show that there are dramatic consequences of the presence of lumpy investments in an economy that is otherwise closer to the textbook example of the monetary transmission mechanism.

As suggested by Johnston (2009) and Reiter et al. (forthcoming), the presence of lumpy investments have implications for firms' price setting decisions, which is the main focus for this paper. The earliest contributions on factor adjustments were by Caballero et al. (1995) and Doms and Dunne (1998) using manufacturing plant data from the US. Their main findings are that investments by manufacturing plants are usually in a lumpy nature, with intense investment activity in short periods and very low investment activity in between the spikes. Secondly, plants' investment spikes have great implications for the aggregate investment fluctuations. Many structural models have been proposed to take the lumpy nature of investment and labour adjustment into account, e.g. Abel and Eberly (1998) using *q*-theory, and Caballero and Engel (1999) (2007), Golosov and Lucas (2003), and Reiter et al., (forthcoming) using a generalized (S, s) model. Gourio and Kashyap (2007) study the effect of investment spikes for U.S. and Chilean plants on aggregate investment rates. Their study shows that most of the aggregate variations could be explained by the number of firms undergoing investment spikes, as opposed to the sizes of the investment spikes. Kahn and Thomas (2008), on the other hand, disagree to these arguments and claim that lumpy investments are quantitatively irrelevant in general equilibrium.

One direction of further research in this field using broad panel data has focused on the relationship between lumpy factor adjustment (capital and labour) and idiosyncratic characteristics including firm performance, labour productivity, and sales. Power (1998) and Sakellaris (2004) using US data, Letterie et al. (2004) for the Netherlands, Nilsen et al. (2009) on Norwegian data and Grazzi et al. (2013) on data from France and Italy. All papers confirm the lumpy nature of investments. Power (1998) find in her paper that there is surprisingly no observable relationship between investment and productivity or productivity growth. Sakellaris (2004) find that productivity even drops after an investment spike, but slowly recovers afterwards. He explains that adoption to new technology by learning how to use them, as well as adapting to a new organization of production, cause the productivity to drop. In Nilsen et al. (2009), a paper on Norwegian data, they find that investment spikes give almost proportional increases in sales, materials, and man-hours. They also find low evidence for any relationship between investments and productivity, and suggest that productivity improvements are explained by trend factors, rather than lumpy investment behaviour. Grazzi et al. (2013) investigates the link between the impact of investment spikes on seven performance variables, including sales, productivity and number of employees. They find that fast growing firms are more likely to invest, and after an investment has taken place, the firms show even further performance increases. When distinguishing expansionary investments, measured by the opening of new plants, they find that such investments have a negative effect on profitability, but are on the same time associated with higher sales and employment levels.

# 3. Theoretical Background

Theoretical models on price and factor adjustments are stylized with several assumptions, and do not fully explain the realistic dynamics we see in real life. It is therefore important to test the theory to empirical evidence. Studies, such as those mentioned above, have found that prices are sticky, meaning that changes are not made continuously. Such lumpy adjustment behaviour is also found in firms' factor demand, such as investment in capital or hiring and downsizing of the labour stock.

## 3.1 Price stickiness

A central aspect of the New-Keynesian economics is nominal rigidities. This refers to the term price and wage stickiness, where the nominal prices and wages are reluctant to adjustment even though the broader market conditions would suggest a different price is optimal.

Mark-up pricing is the most common price setting policy (Fabiani et al., 2005). From this we would expect price adjustments to only occur when the firms' costs change. However, a firm's pricing strategy also depends on the degree of market competition. In the case of perfect competition, the prices are set to a market clearing equal to the marginal cost and there are no mark-ups. In the New-Keynesian framework the firms are assumed to be monopolistic competitors, and can therefore use their market power to keep prices above marginal cost (Álvarez et al., 2006). Even though the market competition is characterized as high, Álvarez et al. (2006) survey results show that most firms still hold some degree of price setting autonomy. Firms often postpone price adjustments until other firms adjust their prices, and this leads to price stickiness because of co-ordination failure.

In addition to cost-based price setting and market competition, theories of explicit and implicit contracts are listed as the main reasons for sticky prices by Álvarez et al. (2006). Contract theories are based on the idea that firms keep long-run contracts with their customers to ensure a stable customer relationship. Such contracts can either be written or oral (explicit), or they can be silent (implicit). In implicit contracts the firm tries to build customer loyalty by keeping price changes to a minimum. This reduces competition from other firms and the customers are able to minimize search costs, as the customer feel safe that the firm is stable and fair.

Because of imperfect information, customers don't have the knowledge or understanding of the firm's costs. This leads to co-ordination failures and customers may want to "penalize" the firm that gives them a bad deal (Rotemberg, 2003). According to Rotemberg (2003), customers use nominal price changes to reflect whether the producers are *fair* or not. The evaluation of fairness of a price change depends on the information the customer has, it is easy to believe that customers have incomplete information of the firm's costs. Firms are therefore either reluctant to frequent price changes or they may add some new features or design to "improve" their product in order to justify a price increase.

Another theory to explain nominal rigidities is "money illusion". Fehr and Tyran (2001) use an experiment to explain that both direct and indirect effects of money illusion explain a large part of nominal rigidities when other factors such as imperfect information, price contracts and cost of adjustment is absent.

The cost of adjustment is another reasonable explanation for price stickiness. Such costs are often referred to as menu costs and are conventionally used to describe the cost of price adjustment in a broader sense. Menu costs might include direct cost of material or labour, but also indirect costs associated with the price adjustment. Such costs have a non-convex nature and will create incentives to postpone any adjustments to the price (Asphjell, 2013). As mentioned in the previous section, Asphjell (2013) finds evidence of menu costs. In contrast, Álvarez et al., (2006) survey reveals that menu costs, pricing thresholds and costly information are not considered important for price adjustment decisions. Others also find that menu costs are of little importance, such as Apel et al. (2001), Blinder et al. (1998) and Hall et al. (2000).

In episodes of investments, Lundin et al. (2009) emphasise the importance of firms' financial constrains as a possible explanation for price rigidities. This implies that the firm will not decrease prices after an investment, as they need the income to pay for the investment. At the same time, it does not increase the prices in fear of losing market share. This is closely related to market competition. If the firm is competing for market share, it is likely that the prices are not related to the firm's costs at all, but is decided outside of the firm's control.

To summarise, the price rigidness may be explained by several factors, such as implicit and explicit customer contracts, cost-based (mark-up) pricing and co-ordination failure. Market competition, money illusion and liquidity constraints in episodes of investments are also empirically significant factors of price rigidness. Menu and information costs are found to be less important (Álvarez et al. 2006).

## 3.2 Time-dependent and state-dependent pricing models

To account for the notion of rational expectations and sticky prices, economists have taken different approaches to the modelling of price adjustment decisions. The New-Keynesian approach is to base structural analysis on firm level decision making. Subcategories of this approach include time-dependent and state-dependent models.

The most prevalent approach is time-dependent models, because it results in a tractable pricing rule, which is easy to aggregate (Gertler and Leahy, 2008). The assumption underlying time-dependent models is that rigidity in the price adjustment decision is exogenously given. Firms either adjust prices at fixed points in time (Taylor, 1980) or according to whether the firm receives a "signal" with constant probabilility independent of time (Calvo, 1983).

The notion of time-dependent pricing is criticized for being overly simplistic. However, some studies on CPI micro data find that particular industries are well approximated with this assumption. A study by Baudry et al. 2004 on French data yielded a time-dependent hazard function for the service industry. However, the other industries studied all had decreasing hazard functions, similar to Bratlie (2013). The decreasing hazard functions violate the underlying assumptions of the time-dependent pricing model.

State-dependent models, on the other hand, rely on the assumption that firms only adjust their prices as a function of the state of the economy. The state dependent (S, s) framework introduced by Arrow et al. (1951) was originally developed for inventory optimization. However, the method applies to almost any firm specific decisions. Different approaches have thus been taken to model various exogenous and endogenous scenarios facing the individual firms. The method is based on optimization around a particular optimal state, which is symmetrically bounded. A state lower or higher than optimal, but within the open bounds, makes it suboptimal to adjust. Only when the firm reaches the bounds, optimization requires the firm to adjust.

Barro (1972) was the first to use the (S, s) framework on monopolistic price adjustment decisions. His approach was to set bounds for the idiosyncratic demand facing a firm. The next approach was introduced by Sheshinki & Weiss (1977). They assumed that general inflation was the cause of price adjustments. Optimal adjustment was therefore obtained on the bounds for the real price.

The newest generation of state-dependent models take into account both idiosyncratic shocks and systematic shocks for price adjustments. Golosov & Lucas (2003) constructed their model to account for idiosyncratic changes in productivity and demand, as well as economy wide shocks. They assume that new technology increases productivity and that price is a decreasing function of productivity.

## 3.3 Cost-based pricing

Firms set their prices according to their costs, their marketing objectives, market competition and other general factors such as government regulations or expected inflation. According to Fabiani et al. (2005) cost-based pricing is the main pricing strategy for most producer industries in the euro area. Cost-based (mark-up) pricing uses the production cost as a basis for pricing and then adds a multiplier for generating profit. The size of the mark-up is not necessary constant over the business cycles and is generally decided on the degree of market competition; the stronger the competition, the lower the mark-up (zero in a free market condition). By studying the interrelation between changes in factor costs and prices we investigate whether cost-based pricing is the preferred pricing strategy in Norwegian producer industries. A close relationship will indicate that Norwegian producer industries are operating in monopolistic competitive markets, and this has implications for the impact of the monetary transmission mechanism.

Wages are a primary source of cost for many firms and many economic models use wages as a measurement for a firm’s marginal cost. In our paper we study the effects of large episodes of labour hiring or downsizing of the labour stock. By using labour stock as a measurement of factor demand instead of wages, we capture the effects of strategic decisions on labour adjustments and the related change in costs, as opposed to changes in wages resulting from labour negotiations or similar circumstances that is not an intentionally strategy from the firms side.

Capital is not freely transferable between periods, and investments entail an initial fixed cost of installation. We also assume that firms face a trade-off between market shares and capital, as suggested by Bucht (1997). The firms must choose between high prices that generate high profits today, and low prices that may increase market share and increase profits in the future. When firms are financially constrained, cost-based pricing may be countercyclical. In a recession, firms abstain from reducing prices in order to maintain their cash flow. During booms they may decrease their prices in an aggressive market strategy in order to gain market share. Similarly, we would expect this behaviour in the context of episodes of investment in physical capital. When facing high demand, the need for investments in capital increases, which makes the firms more financially constrained, which then leads to decreased prices of output before the investment to ensure a market share (Lundin et al., 2009). If on the other hand, the firm is not financially constrained, it is able to reduce its prices to gain market share in a competitive market. In a monopolistic market, the firm would increase the price in a mark-up sense in response to the increased investments and demand. The pricing strategy of the firms is again dependent on the degree of market competition. It seems from theory that the less market competition there is, the closer the relationship between price adjustments and factor investments.

# 4. The Data

## 4.1 Norwegian manufactoring industries

The dataset used in this paper is from the Commodity Price Index for the industrial sector (VPPI). The data is obtained by SSB through monthly price surveys from about 1,300 establishments and addresses the establishment's products and prices collected from the Norwegian manufacturing industries. The Commodity Price Index for industrial sectors (VPPI) is closely connected to the Producer Price Index (PPI) and the Price index first-hand domestic sales (PIF), as they come from the same questionnaires and electric reporting. The difference between VPPI and PPI is that VPPI are subject to revisions. The purpose of VPPI is to measure price developments on first hand sales of products in the Norwegian market, from Norwegian production and export. The individual products' price observations are grouped in different ways in order to observe price patterns at a sectoral level.

Mandatory participation ensures a high response rate. All forms are manually checked and electronic data have automatic controls in order to identify very large price changes, punching errors, duplications or non-response. The firm is contacted in case of such errors. If prices are not available the price data is calculated.

The monthly micro data of the VPPI collected by SSB allow us to analyse price setting behaviour across a wide span of industries. At the aggregate level these data describe the actual inflation on the producer level.

As a part of SSB's industry statistics the dataset also includes detailed information regarding the number of employers, wages, costs, investments, and the like. This only includes the manufacturing, mining, and quarry sectors. Therefore, other sectors such as agriculture, energy, transportation, and service industries are not included in the analysis of this paper. The observations are grouped by industry, based on the Standard Industrial Classification (SIC2002), which classifies products in accordance to which economic activity the product belongs. The SIC is one of the most important standards in economic statistics and is based on the EU classification standard, NACE Rev. 1.1. By having this standardized classification of products it makes it possible to compare and analyse statistical data both at an international level and over time. The SIC2002 codes are provided as a five-digit number as the most detailed level of classification. Based on the SIC2002 codes the products are further grouped into three-digit product sector codes and two-digit industry sector codes. A list of the product sector codes and industry sector codes are presented in appendix 1 and 2.

SSB (2007) highlights that as new industries and industrial structure change over time, the industry standard classifications also need to change. Therefore, a new Standard Industrial Classification (SIC2007) replaced the SIC2002 from the beginning of 2009. The new classification, based on NACE rev. 2, is more detailed and has more subgroups, especially in the service sector. In addition to the increase in scale, the number codes has also changed in the new standard. The dataset used for the empirical analysis spans from 2002-2009. In this regard, the sector codes in 2009 are set to what they were the previous year.

The dataset have been further washed in preparation to this paper's analysis. First, given our interest in tracking firms' behaviour patterns over time, we consider only firms reporting data for at least tree consecutive years. The sample only includes privately owned companies with more than 10 employees and no multi-plants firm. Yearly growth rates for wage and sales outside the [0.01, 0.99] interval are not included. Additionally, since very large monthly price changes are believed to reflect quality changes and not only simple month-to-month pricing decisions, observations of price changes outside the [0.01, 0.99] interval have been identified as new products (Asphjell 2013).

Information on labour stock and investments are given on a yearly basis. With this in mind, we needed to aggregate the monthly price changes to yearly changes in the prices. We have done this by finding the arithmetic average of a product's price over a year and use this to find the annual price change. This is more clearly described as follows:

$$\frac{\left(\frac{P_t^{Jan}+P_t^{Feb}+\cdots+P_t^{Dec}}{12}\right)-\left(\frac{P_{t-1}^{Jan}+P_{t-1}^{Feb}+\cdots+P_{t-1}^{Dec}}{12}\right)}{\left(\frac{P_{t-1}^{Jan}+P_{t-1}^{Feb}+\cdots+P_{t-1}^{Dec}}{12}\right)}=\frac{\bar{P}_t-\bar{P}_{t-1}}{\bar{P}_{t-1}}$$

The advantages of using a panel dataset are that we are able to reduce multicollinearity problems because we have variations between the cross-sections and over time. By using panel data instead of one cross-section or time-series, we are also able to control for unobserved effects for a firm or product characteristics.

## 4.2 Descriptive data

### Price adjustments

The dataset used in this paper is an unbalanced panel that consists of 93,696 individual monthly price observations. Moreover, we have 91,902 observed price changes. By performing the aggregation procedure of prices in the previous section we are left with 7,816 annual price observations and 6,014 annual price changes. These are from 342 firms with an average of about 5 products, and a total of 1,798 individual products. The observations are distributed across 23 different industries and span from 2002 to 2009.

***Table 1*** *- Descriptive data on price changes*

**Price Changes**

Monthly

| | Observations | Fraction | Mean | Median | St. dev. | Min | Max |
|---|---|---|---|---|---|---|---|
| Positive | 12,967 | 14.1% | 4.5% | 2.8% | 6.2% | 0.0% | 97.1% |
| Negative | 8,136 | 8.9% | -3.9% | -2.0% | 5.3% | -52.0% | 0.0% |
| Pricing Activity | 21,103 | 23.0% | 4.3% | 2.5% | 5.9% | 0.0% | 97.1% |
| Total Sample | 91,902 | 100.0% | 0.3% | 0.0% | 3.5% | -52.0% | 97.1% |

Yearly

| | Observations | Fraction | Mean | Median | St. dev. | Min | Max |
|---|---|---|---|---|---|---|---|
| Positive | 4,144 | 68.9% | 6.4% | 4.4% | 7.3% | 0.0% | 97.3% |
| Negative | 1,053 | 17.5% | -6.1% | -3.8% | 6.7% | -52.8% | 0.0% |
| Pricing Activity | 5,197 | 86.4% | 6.3% | 4.3% | 7.2% | 0.0% | 97.3% |
| Total Sample | 6,014 | 100.0% | 3.3% | 2.5% | 8.3% | -52.8% | 97.3% |

The table above (table 1) shows the descriptive statistics for the price changes. Of the monthly price change observations we have 12,973 positive observations and 8,137 negative. The difference is high with 4,836 more positive changes than negatives ones. The average size of monthly price adjustments is 0.28 % for all price adjustments. For positive price changes the mean is 4.5 %, and the absolute value of the negative mean is 0.5 percentage points lower.

For the annual price changes we have 4,148 positive observations, and 1,053 negative observations. Because we have aggregated the monthly prices by taking the average, the yearly prices are robust to mean-reverting prices. The average yearly price change is about 3.31 %, which is rather high for producer prices. Carlsson et al. (2012) found in their study of Swedish producer prices an average yearly price adjustment of 1.8 %. The mean of the annual positive changes is 6.4 %, and for negative changes the mean is -6.1 %.

The monthly price adjustment frequency is about 23 % and the yearly is about 86.4 %. This corresponds well to the findings of Carlsson et al. (2012), who find annual price change inaction of 13.6 %. These finding support the notion that prices are rigid.

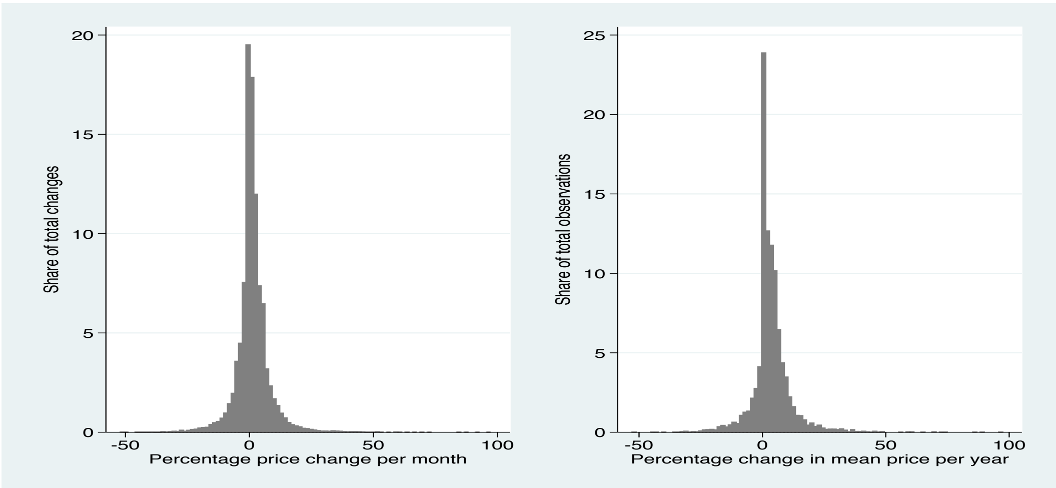


***Fig. 1*** *- Distribution of price changes*

In figure 1 above we have plotted the monthly and annual price changes observed in the dataset. We see that both panels have large spikes, which are positively skewed. Note that we have left out monthly price change observations of inactivity.

Next, we investigate how the distributions of price changes vary between the sectors. As can be seen from the figure 2 there is considerable differences in the mean change per year and the frequency of changes per year. Note that the mean price change in the graph is measured in absolute terms. It is apparent that sector 27 (manufacture of basic metals) stands out, with an average of about 6 changes per year and an average annual price change of almost 10 %.

The average number of price changes per year is about 3 for the whole sample. Bratlie (2013) finds for the same dataset an average weighted mean duration of 3.4 months, which corresponds well with this finding.

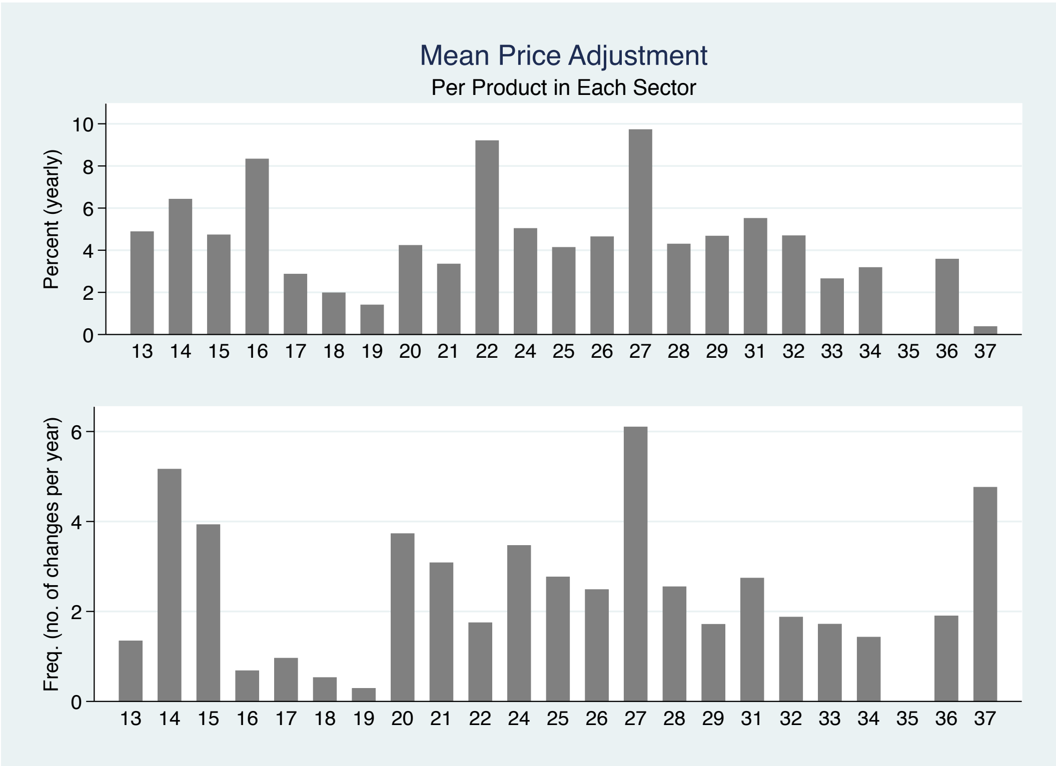


***Fig. 2*** *- Mean and frequencies of price changes*

## Capital investments

The firms' capital investment ratio is the investment over tangible fixed assets. In particular, the capital investment rate in year *t* is measured by $I_t/K_{t-1}$. Fixed assets, *K*, is artificially constructed using the fire insurance value of machinery from the base year 1996. The replacement value is computed using the perpetual inventory method as described by Asphjell et al. (2010). Here the fixed assets, *K*, are calculated using the formula[3]: $K_t = (1-\delta)K_{t-1} + P_t - S_t$, where the depreciation rate $\delta$ is set to 0.06 and $P_t$ is purchases in capital goods and $S_t$ is sales. For some of the observations it turns out that sales of capital, $S_t$, is larger than the replacement value, $K_{t-1}$. If so, the replacement value has been built up from the beginning on by setting the initial replacement valued for this firm such that the

[3] Calculations conducted by Øivind Anti Nilsen.

replacement value is positive over all the years. Unfortunately, some of the firms in the dataset did not yet exist in 1995, therefore different analyses conducted later using the capital investment rate as one of the variables have a reduced dataset. In these regressions we have only 324 firms contrary to 342. In addition, we exclude observations where capital investment rates exceed the interval [-0.5, 2]. The different firms are categorized in both three-digit product group sectors and in two-digit industry sectors. One firm is only registered in one product group and one industry even though it may produce different products. The investment rates are therefore linked to the firm's capital and activity, not to the individual products.

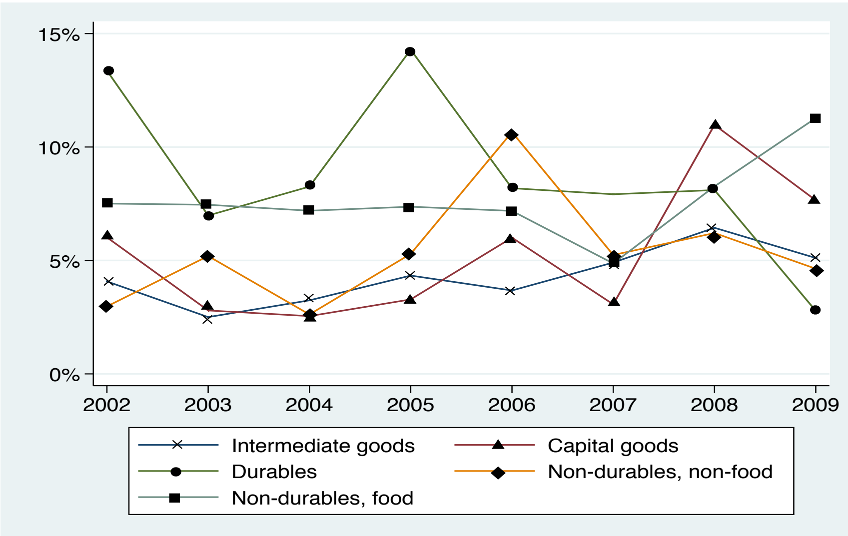


***Fig. 4** - Investment ratios by product groups*

Figure 4 shows that the aggregate average net investment rates for equipment capital over the sample years for the different product groups were mostly between 2 and 8%. The averages are weighted by the firm's share of the industry's total capital stock. We see that the investment rates are relatively stable over the years for three of the product groups (intermediate goods, capital goods and non-durables (food)). Durables and non-durables (non-food) on the other hand, seem to be quite volatile over the eight-year period. All product groups, but food, decrease in 2009; this was probably in context of the financial crisis starting the fall of 2008. We use the net investment ratio in our analysis and may therefore have negative investment ratios for some firms in some of the years. Our justification for using net investments is that we are interested in factor demand and not particularly new technological change. When we use net investments as opposed to only positive investments, we avoid biasness towards more successful firms. As a result of using net investments we get investment ratios that are quite low. Norwegian tax legislation requires a depreciation rate of machinery and equipment of 20%. The low investment rates may indicate that the artificially constructed capital values are estimating the real capital stock too low. However, we are interested in changes in investment behaviour and therefore the level of average investment does not induce big problems for us.

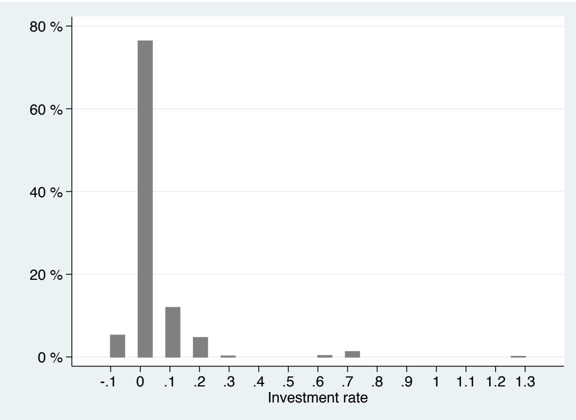


***Fig. 5*** *- Histogram of investment rates in 2005*

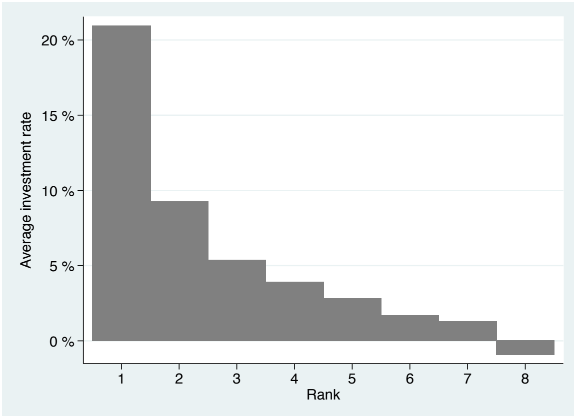


***Fig. 6*** *- Investment shares by rank*

The firms' investment patterns are investigated both across firms and within firms. Figure 5 shows investment rates in the year 2005. From this figure it is evident that firms' investment rates are low (the other years' distributions are similar). More than 70 % of the firms had an investment rate of less than 10 % in 2005. This seems rather odd as 2004 to 2007 are characterized by a booming economy. There are, however, several investment observations larger than 20%, indicating that some firms invested intensively. This points to differences across firms, next we want to investigate investment differences within any one firm to find out how firms decide to allocate investments over the period. By doing this we assess the degree of lumpiness of investments. Figure 6 shows that the highest share of investments in any one year on average accounts for more than 20% of total investments. The ratios of investment in the other years are significantly lower, indicating a lumpy nature of investments in capital. These reported evidence are similar to the investment patterns described by Grazzi et al. (2013) for France and Italy.

## Labour stock

Data on labour is reported annually and all firms with less than ten workers are excluded from the dataset. We can see from figure 7 that small and medium sized firms (less than 100 workers) are overrepresented in the sample and only a small per cent of the sample is very large companies (more than 100 workers). The mean number of workers is 113, and the median is 63. This means that we may take the size into consideration when doing further analysis, as the distribution is very skewed. In figure 9 and 10 the average number of workers is plotted according to the five different product groups and industry sectors. Figure 9 show that the number of workers varies significantly between sectors, Figure 10 show that non-durables (food) is especially more labour intense than the other product groups. Because of these observations we will conduct regressions both on product group level and on industry sector level to see if the labour intensity has a contributory effect on the estimates.

Labour adjustment is measured by $\Delta L_t / L_{t-1}$. Labour adjustment distribution is presented in figure 8. It is apparent that most labour adjustments, both positive and negative, are small as figure 8 show, in fact the average adjustment rate in labour is zero. Furthermore, figure 11 show the average labour adjustment rates weighted by the share of total industry labour stock. The overall picture of the average labour adjustments is that it for most sectors decreased from 2003 and then increased from 2004 to 2007 and then fell sharply from 2007 to around -5 % in 2009, indicating that firms downsized and fired people in the unstable time of the financial crisis. The negative and low rates of labour investment are quite puzzling as the unemployment rate over the period was low and stable at around an average of 3.5 % (SSB, 2013). It is important, however, to note that negative labour adjustments not only be firings, but it may represent resignations. Increased resignations one year may be the result of mergers or relocation.

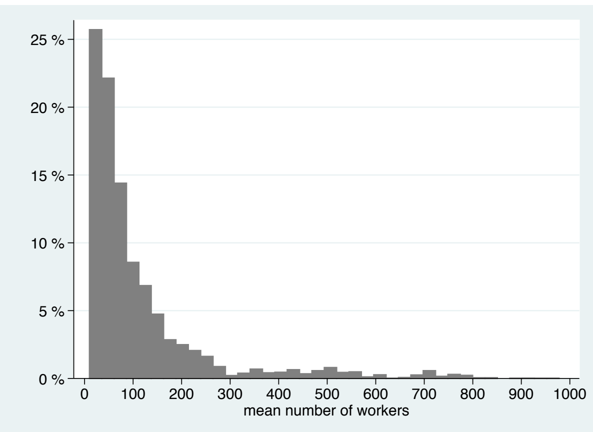


***Fig.** 7 - Histogram of firms' labour stock*

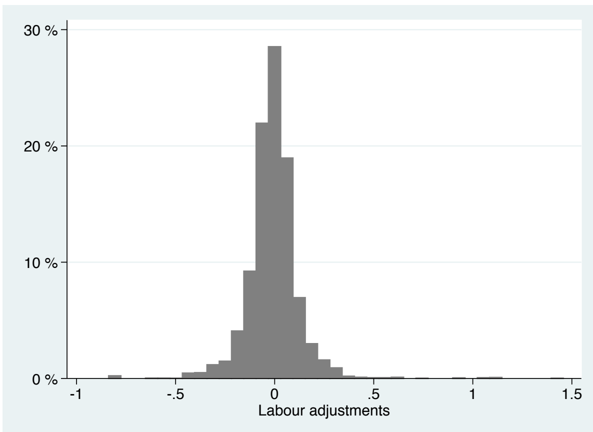


***Fig.** 8 - Histogram of labour adjustments*

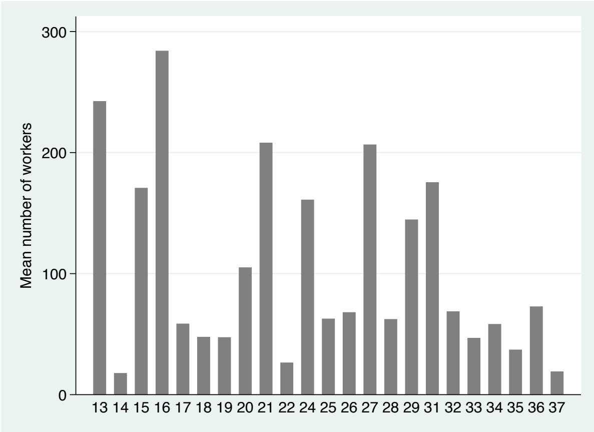


***Fig. 9*** *- Mean number of workers by sector 2 digit code*

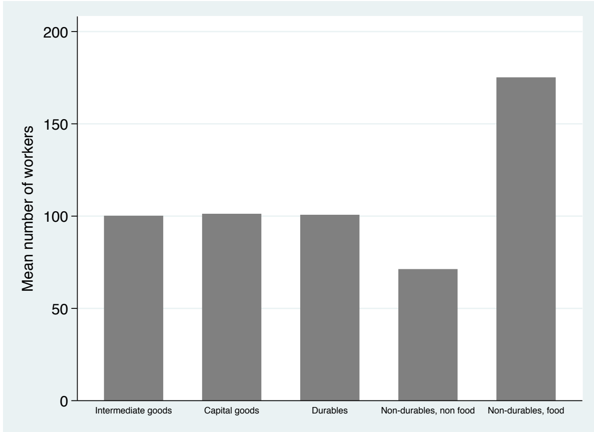


***Fig.10*** *- Mean number of workers by product group*

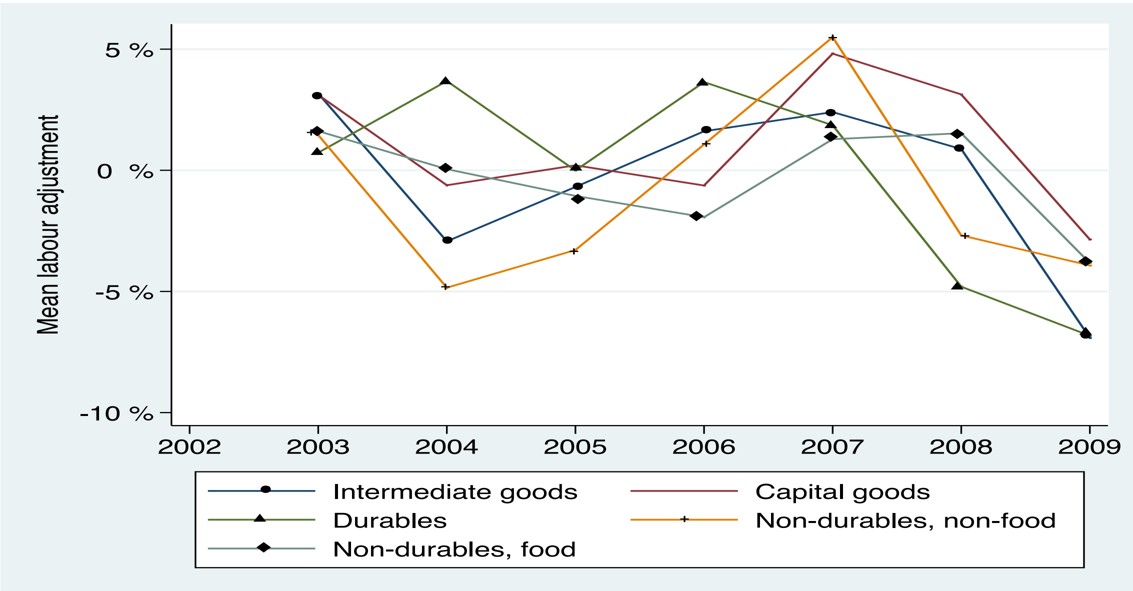


***Fig. 11*** *- Labour stock adjustment by product group*

In order to evaluate the nature of labour adjustments we proceed using the same method as with investments in capital. We divide the observations into positive and negative labour adjustment episodes. First, looking at labour adjustment rates across different firms we find from figure 12 and 13 that most labour investment rates are close to zero. In fact, 80-90% of all positive labour investments are less than 10 % and 60-70 % of all negative labour adjustments are more than -10 %. Still there are labour adjustments spreading further away from these small adjustments in both directions. Second, similar to investments in capital, investments in labour is clustered within one year. The highest share of hiring is about 14 %, and the other years in the sample period is significantly lower. We see the same pattern in downsizing of the labour stock. These findings correspond to lumpy rates of labour adjustments.

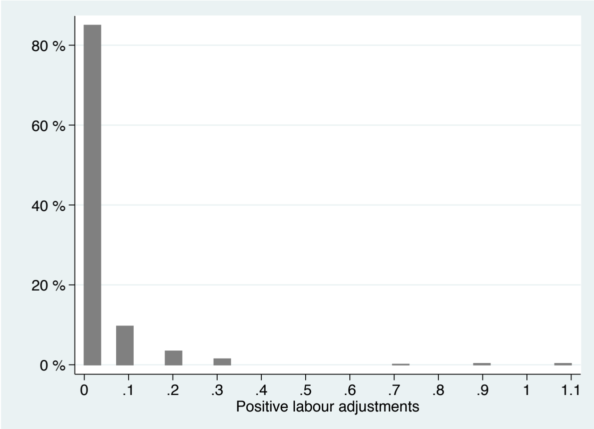


***Fig. 12*** *- Histogram of hiring rates in 2007*

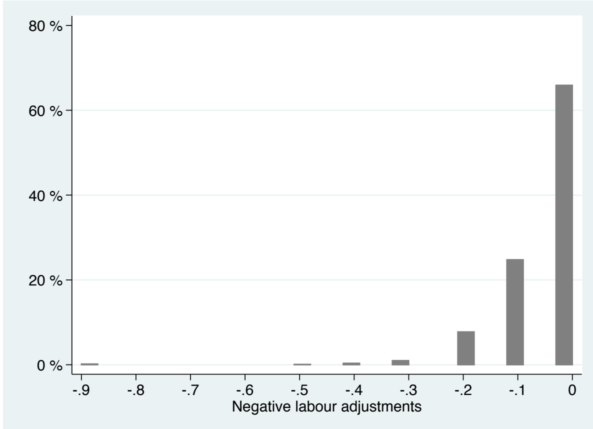


***Fig. 13*** *- Histogram of downsizing rates in 2007*

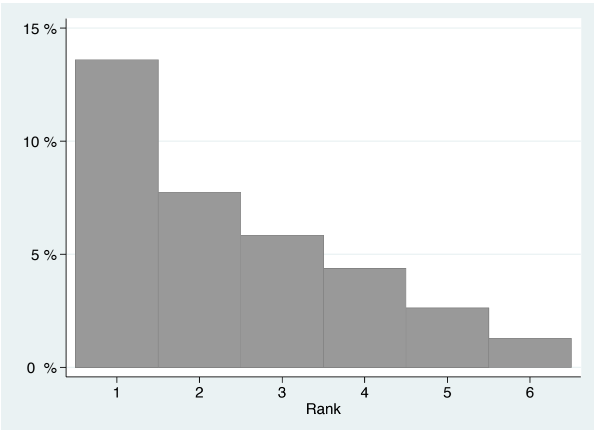


***Fig. 14*** *– Hirings by rank*

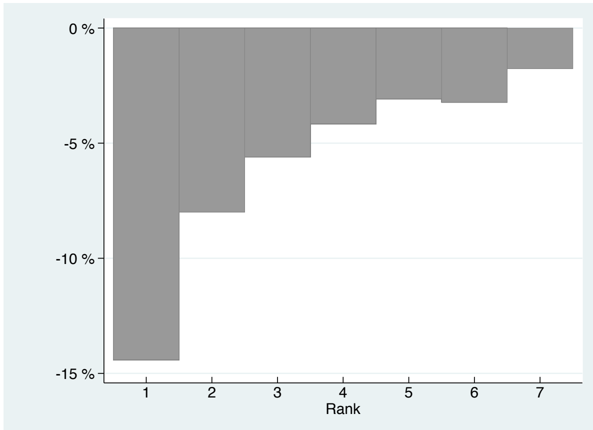


***Fig. 15*** *– Downsizing by rank*

## 4.3 Measurement of factor adjustment spikes

### Identifying investment spikes

There are many types of investment, including replacement, retooling and expansion. Some of these investments are motivated by increases in capacity, while others are motivated by increases in productivity. The presence of lumpy investments as described in the previous section may be a response to monetary shocks and may represent firms' expectations of future economic business. We will investigate how lumpy investments affect price setting behaviour, and by this investigate lumpy investments' effect on nominal rigidities. The focus is on investment spikes, which are investments that are large and infrequent. In this section we present four alternative methodologies for identifying investment spikes, namely the absolute rule, the relative rule, the linear rule and the kernel rule.

The absolute rule uses a specific threshold to identify spikes, often set to 20% as in Cooper et al. (1999) and Sakellaris (2004). The threshold is set to eliminate routine maintenance expenditures. So if the firm report an investment rate of more that 0.2 to capital in one year, and the proceeding year have a ratio less than 0.2, then we observe a spike.

Power (1998) emphasises that an investment spike is defined as a large investment outside of the normal investment pattern of a firm. She therefore presents the relative rule, which identifies an investment spike if the investment ratio exceeds the median investment ratio over a certain period, $\tau$, by a scaling parameter, $\alpha$. The relative spike is expressed as:

$$I_{i,t}/K_{i,t-1} > \alpha \ \underset{\tau}{median}(I_{i,\tau}/K_{i,\tau-1})$$

Power (1998) suggests three different values to $\alpha$, but choose the least stringent criterion of 1.75. By using the relative rule, we may get observed investment spikes less than 20%. Power (1998) therefore combines the relative and the absolute rule to identify investment spikes. Then the spike is identified when:

$$I_{i,t}/K_{i,t-1} > \max\left[\alpha \ \underset{\tau}{median}(I_{i,\tau}/K_{i,\tau-1})\,, 0.2\right]$$

Small firms often have higher volatility of investment rates than larger firms. This means that the probability of observing a spike is greater for a small firm than for a large firm. In order to take this into account, Nilsen et al. (2009) propose a rule where the threshold value conditions on the size of the firm. They show that investment rates have a negative relationship with the capital stock. By applying a linear rule, we can correct for the excessive volatility of investment for smaller firms. The linear rule expresses a spike as:

$$I^e_{i,t}/K^e_{i,t-1} > \max\left[\alpha\,\mu\, E[(I^e_{i,t}/K^e_{i,t-1})|K^e_{i,t-1}]\ , 0.2\right]$$

where the first term inside the max operator is the conditional expectation of the investment rate multiplied by α, which is chosen to be 1.75. The estimated value can be negative and therefore the linear rule is combined with the absolute rule.

Finally, Grazzi et al. (2013) propose a forth method of identifying investment spikes. They argue that the linear relation underestimates the investment rates of the smallest and the largest firms. They therefore employ a non-linear kernel fit to identify investment spikes. An advantage with this approach is that the kernel estimation will never get negative, and there is therefore no need to combine it with an absolute rule. An investment spike by the kernel rule is identified as:

$$I_{i,t}/K_{i,t-1} > \alpha E[(I_{i,t}/K_{i,t-1})|K_{i,t-1}]$$

When evaluating the different measurement methods of investment spikes we find that the capital investment rate does not notably differ between small and large firms. In fact, the linear rule identified spikes identically to the absolute rule; 521 spikes and 7.8 % of total investments. In this respect we do not need to use the kernel rule either, as the investment rates do not differ much for small and large firms. Using the relative rule, combined with the absolute rule as Power (1998), we find 475 spikes, which corresponds to 7.1 % of total investments. We choose to use the relative rule in Power's tradition as this takes the characteristic of the firm into account when identifying spikes.

In the event of a multiyear spike, i.e. large investments episodes lasting for more than one year, we do not take this particularly into account when defining a spike. This is taken into account when formulating the model later. Our measurement for capital investment spikes used in the following analysis is therefore:

$$I_{i,t}/K_{i,t-1} > \max\left[\alpha \underset{\tau}{median}\left(\frac{I_{i,\tau}}{K_{i,\tau-1}}\right), 0.2\right]$$

Descriptive data on the spikes with different values for $\alpha$ are presented in table 2. When running the regressions with different values of $\alpha$ it is evident that the qualitative results do not appear to be dependent on the value of $\alpha$. We therefore set $\alpha$ to 1.75 following Power (1998) and Nilsen et al. (2009), as this increases the robustness of this paper. Figure 16 displays the average investment rates around a spike. The spike is reported in period *t* and *t-5,…, t-1* are five years before the spike and *t+1 ,…, t+7* are seven years after the spike. The average size of an investment spike in capital is 40% and significantly differs from the investment rates before and after the investment episode, as depicted in the figure. This points to clearly lumpy adjustment behaviour in capital.

***Table 2*** *- Descriptive data on capital investment spikes*

| | | | **Combined rule** | | | |
|---|---|---|---|---|---|---|
| **α** | Share of total observations | Share < 100 employees* | Share > 100 employees** | Mean | Median | Percent multi - spikes |
| 0,0 | 7.8% | 7.7% | 8.2% | 39.1% | 27.8% | 17.1% |
| 1,75 | 7.1% | 7.1% | 7.2% | 40.0% | 28.2% | 14.3% |
| 2,50 | 5.5% | 5.3% | 6.1% | 43.0% | 31.0% | 11.4% |
| 3,25 | 4.7% | 5.0% | 4.2% | 46.0% | 34.0% | 9.2% |

*Note: *Share of investment spikes attributed to firms with less than 100 employees.*
***Share of investment spikes attributed to firms with more than 100 employees.*

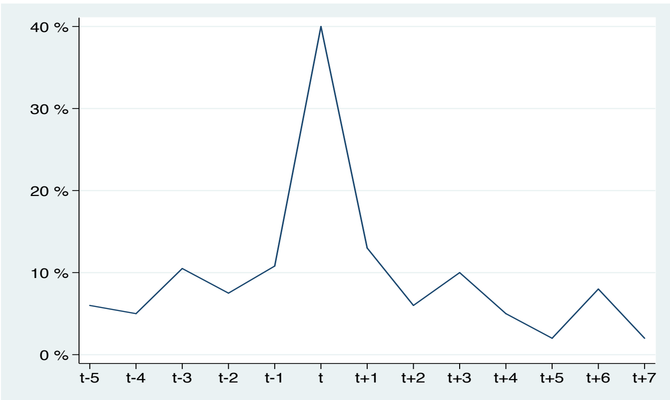


***Fig. 16*** *- Average investment rates around a spike*

## Labour spike measurement

Labour costs represent the marginal cost of producing products. Large changes in marginal costs would lead to an equivalent change in prices if we believe that firms use a mark-up based price setting strategy and the firms operate in a monopolistic market. From the previous section we found that labour adjustments have a lumpy nature, just as investments in capital. This means that firms undergo large hiring or firing episodes confined within a year.

When identifying labour spikes, many of the same considerations apply as with investment spikes. Firm-specific characteristics have implications for the labour stock adjustments, such as size and age. We will therefore use the relative rule combined with the absolute rule, again with α=1.75 (see table 3 for comparison of different α's). Contrary to investment spikes, labour adjustment spikes may be either positive or negative. We must therefore, as Sakellaris (2004) propose separate rules for episodes of hiring and episodes of firing (or resignations). Labour investment spikes are therefore measured as follows:

$$\Delta L_{i,t}/L_{i,t-1} \begin{cases} > \max\left[\alpha \underset{\tau}{median}\left(\frac{\Delta L_{i,\tau}}{L_{i,\tau-1}}\right), 0.10\right] \\ < \min\left[\alpha \underset{\tau}{median}\left(\frac{\Delta L_{i,\tau}}{L_{i,\tau-1}}\right), -0.10\right] \end{cases}$$

The average adjustment rate is around zero and varies from negative 83.8 % to positive 145.7%. Using the relative rule described above, 22.5% of labour adjustments are spikes, where we have 573 positive spikes with an average hiring adjustment of 20.6%, and 681 negative spikes with an average downsizing adjustment of -20.6%. If we were to follow Sakellaris (2004) and use the absolute rule definition, it would give us 28% spike observations. As these two definitions do not differ too much, and the relative rule also considers the firms' characteristics, we choose to only consider the relative rule throughout this paper.

It is evident from figure 17 that episodes of hiring often start in one year and then spike in the next. This is probably due to training time and other adjustment costs. However, this is not analysed further in this paper. On the other hand, large episodes of firing are concentrated to one peak year. This characteristic of employment adjustment underlines the finding of Sakeallaris (2000) on production-workers only.

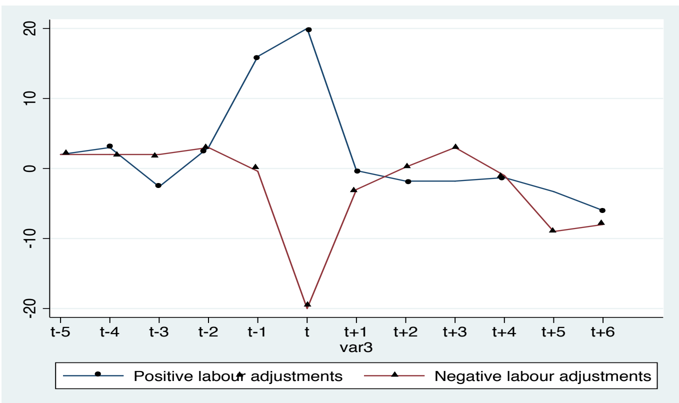


***Fig. 17*** *- Average labour stock adjustment around a spike*

*__Table 3__ - Descriptive data on labour spikes*

| Comparing spike rule definitions | | | | | | |
|---|---|---|---|---|---|---|
| **Positive Labor Spikes with the combined rule** | | | | | | |
| **α** | Percent of total observations | Share < 100 Employees* | Share > 100 Employees** | Mean | Median | Percent multi-spikes |
| 0.00 | 12.0 | 13.3 | 9.2 | 20.3 | 16.7 | 13.8 |
| 1.75 | 10.3 | 11.5 | 7.8 | 20.6 | 16.7 | 8.0 |
| 2.50 | 8.7 | 9.6 | 6.8 | 21.0 | 16.7 | 7.8 |
| 3.25 | 7.1 | 7.8 | 5.7 | 21.8 | 16.7 | 7.3 |
| **Negative Labor Spikes with the combined rule** | | | | | | |
| **α** | Percent of total observations | Share < 100 Employees* | Share > 100 Employees** | Mean | Median | Percent multi-spikes |
| 0.00 | 16.0 | 19.0 | 9.5 | -19.2 | -15.8 | 17.1 |
| 1.75 | 12.2 | 14.2 | 7.9 | -20.6 | -16.7 | 10.3 |
| 2.50 | 9.8 | 11.1 | 7.0 | -20.5 | -17.2 | 9.3 |
| 3.25 | 8.6 | 9.6 | 6.4 | -21.0 | -16.7 | 10.0 |

*Note: *Share of labor spikes attributed to firms with less than 100 employees.*

***Share of labor spikes attributed to firms with more than 100 employees*

# 5. Methodology

The main objective of this paper is to investigate how firms adjust prices in periods of large factor adjustments (capital and labour), and in periods before and after such spikes. Our dependent variable for investigating this is therefore relative price change. The empirical model is estimated both using a multilevel random intercepts model by maximum likelihood estimation, and with an LSDV longitudinal model approach. Distinct events of large adjustment i.e. spikes, have been described in detail in section 4.

Building on Power (1998), Sakellaris (2004), Letterie et al. (2004), Nilsen et al. (2009) and others we define a vector of covariates as follows:

$$\begin{bmatrix} X_{1j}^{h} \\ X_{2j}^{h} \\ X_{3j}^{h} \\ X_{4j}^{h} \\ X_{5j}^{h} \\ X_{6j}^{h} \end{bmatrix} = \begin{bmatrix} max_{T_j^{start} \leq \tau \leq T_j^{end}} S_{j\tau} \\ S_{jt} \\ (1 - S_{jt})S_{jt-1} \\ (1 - S_{jt})(1 - S_{jt-1})S_{jt-2} \\ (1 - S_{jt})(1 - S_{jt-1})(1 - S_{jt-2})max_{\tau \leq t-3} \\ (1 - S_{jt})S_{jt+1} \end{bmatrix}$$

The first indicator will have the value 1 if the firm has experienced at least one spike during the reported period, thus representing a sort of fixed effect for the group of firms reporting at least one factor adjustment spike. The superscript, *h,* indicates the type of spike, whether it is an investment spike or a positive- or negative labour adjustment spike. The second component indicates if there is a spike in factor adjustment the same year as the price change, year *t.* Component three and four, $X_{3j}^{h}$ and $X_{4j}^{h}$, denote whether there was a spike in the year before or two years earlier, but not in year *t* or in *t and t-1,* respectively. The fifth component $X_{5j}^{h}$, indicates if there has been a spike during the period of $[T_j^{start}, t-3]$, but not in *t-2, t-1* or *t.* This component captures potential shifts in the aggregate level of $X_{jt}^{h}$, relative to the normal level before the spike. This can be interpreted as the long-run effect of spikes on price adjustments (Nilsen et al., 2009). Finally $X_{6j}^{h}$ indicates whether there will be a spike in the year after *t*. If the firm experiences a multiyear investment episode the $S_{jt} = X_{2j}^{h}$ will equal 1 for all years of investment, and $X_{3j}^{h}$ will equal 1 only in the year after the last year of the multiyear spike.

Our dataset can be considered to have a hierarchical structure with four identifiable levels containing factors we believe can each partially explain the variation in the observed price adjustments: (i) time: repeated measures on price- adjustments are “nested” within a specific product (within-product variation), (ii) product-specific characteristics (between-product variation), (iii) producer-specific characteristics (between-producer variation) and (iv) sector-specific characteristics (between-sector variation).

To account for the structure of our dataset and to investigate its implications, we apply a multilevel random intercepts model (also refered to as a mixed model)[4]. This can be seen as a random effects regression where we include a random component for each level. We thereby account for unobserved effects on more than one level. It seems reasonable that there are between-effects on all the levels. However, since price setting is predominantly a firm-level decision, we believe most between-variation is found here. In our model we therefore have four possible random intercepts that are assumed to be independent and identically distributed (iid). Thus, the total variance of the dependent variable (price change) is therefore the sum of the variances. The following assumptions are made about the random intercepts (Rabe- Hesketh and Skrondahl, 2005):

$$\zeta^{(i)} \sim N\left(0, \psi^{(i)}\right),\ \zeta^{(j)} \sim N\left(0, \psi^{(j)}\right),\ \zeta^{(k)} \sim N\left(0, \psi^{(k)}\right) \text{ and } \epsilon_{t,ijk} \sim N(0, \theta)$$

In the specification above, $\zeta^{(i)}$ is the product-specific random effects nested within a producer and sector, $\zeta^{(j)}$ is the producer-specific random effects nested within a sector, and $\zeta^{(k)}$ is the sector-specific random effects. $\epsilon_{t,ijk}$ is the residual error associated with a specific price change for product *i* within the *j*th producer and *k*th sector at time *t*.

The resulting model based on these assumptions is therefore:

$$\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)_{t,ijk} = \beta_1 \left(X_1^h\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^h\right)_{t,j} + \zeta^{(i)} + \zeta^{(j)} + \zeta^{(k)} + \eta + \epsilon_{t,ijk}$$

[4] We also considered applying the more general multilevel model with random coefficients. This model specification, however, did not converge for all regressions. See Rabe-Hesketh and Skrondal (2005) for information about these models.

In this specification, $\eta$ are time dummies. By including time dummies we control for aggregate trends in the variables and, more importantly, other aggregate dynamics in the data that may be unrelated to the factor adjustment we study.

Using the model specified above we have three variations with different regressors depending on the type of spike we are investigating: (i) capital investment spikes, (ii) positive labour adjustment spikes and (iii) negative labour adjustment spikes. Additionally, we further investigate the variations across firms by also performing the econometric analyses on the different product groups; *intermediates, capital goods, durables, non-durables non-food, non-durables food*, on the different SIC 2-digit sectors, as well as on the total dataset. This approach allows the coefficients, and thus the intertemporal effects of a spike, to vary between the product groups and sectors.

To investigate the importance of each level in our model, we calculate the intraclass correlation coefficient for the entire sample. This is a ratio of the variances of the random effects to the total variance of price change observations. For example, the intraclass correlation (ICC) for the sector- level is calculated as[5]:

$$\rho(sector) = \frac{\psi^{(k)}}{\psi^{(i)} + \psi^{(j)} + \psi^{(k)} + \theta}$$

We find that the sector- level ICC is below 0.5%, which means that the between- sector variation is very small. Furthermore, the producer- level ICC is quite large at around 14%. Finally, the product-level ICC is close to zero, which implies that the within-producer between-product random effects account for very little variance of the price-changes in our model. These results show that the producer- level random effects account for most of the random effects between the clusters of observations. Likelihood ratio tests on the specifications confirmed that only the producer-specific random effects are statistically significant. We therefore leave out both product- and sector-random effects in the model when estimating coefficients.

---

[5] Using the Stata command iccvar after running the command xtmixed

The resulting model for measuring the effects on price change for product *i,* in firm j is presented as follows with the multilevel random intercepts model[6]:

$$\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)_{t,ijk} = \beta_1 \left(X_1^h\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^h\right)_{t,j} + \zeta^{(j)} + \eta + \epsilon_{t,ijk}$$

In this specification, $\zeta^{(j)}$ is the unobserved random effect at the firm level, and $\eta$ are time dummies.

We have discovered that most of the unobserved effects can be explained by firm-level factors. For comparison and robustness we also employ an LSDV-model using OLS-estimation where we include firm-level dummy variables. This approach is similar to that of Power (1995) and Sakellaris (2003), who use an LSDV-model when they study the effects of lumpy investments on firm performance. The LSDV-approach will in this case yield equivalent results as using the within estimator for eliminating fixed effects. However, as opposed to the within-estimator, we include the unobservable effects as dummy variables. This approach lets us calculate the degrees of freedom directly from the specifications and also allows us to include time invariant regressors. However, the method is computationally more extensive since we need to compute estimates for the unobserved effects rather than removing these. To account for the clustering of observations, we apply a special estimator for the standard errors[7]. This estimator both adjusts for heteroskedasticity and autocorrelation. The LSDV model can be illustrated as:

$$\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)_{t,i} = \beta_1 \left(X_1^h\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^h\right)_{t,j} + \zeta^{(j)} + \eta + \epsilon_{t,i}$$

Here, the $\zeta^{(j)}$ are the firm- level dummies and $\eta$ are the time dummies. The rest of the model is explained in relation with the multilevel approach.

---

[6] Using the Stata command xtmixed

[7] Using the Stata option vce(cluster *clustervar*) for the regressions.

## 5.1 Discussion of methods

The most common and convincing econometric approach to modelling panel data is to treat the unobserved effects as time-invariant fixed effects (Wooldridge, 2013). This way, any endogeneity bias is reduced to a minimum since the regressors are allowed to be partially correlated with the unobserved fixed effects. This can be illustrated as: $cov(\boldsymbol{X}_{j,t}, \zeta^{(j)}) \neq 0$, where $\boldsymbol{X}_{t,j}$ is the vector of the explanatory variables. Nevertheless, after accounting for the the time invariant effects we must have strict exogeneity in the model: $E(\epsilon_{t,ij} | \boldsymbol{X}_j, \zeta^{(j)}) = 0$, for all $t = 1,\ldots,$T.

However, if one believes that the unobserved effects are uncorrelated with the observed regressors in the model, a random effects model is the more efficient approach (Wooldridge, 2013). By treating the unobserved effects as random, we make the assumption: $cov(\boldsymbol{X}_{j,t}, \zeta^{(j)}) = 0$. In a multilevel model, this assumption means that the unobserved effects on all levels must be uncorrelated with the regressors. This is a strict assumption, and violation may lead to incosistent estimators.

It is reasonable to assume that the within-level observations of the dependent variable are correlated. For example, within the same sector and producer the observations will tend to be more similar than if the observations were sampled randomly from many producers. Additionally, as we move down the hierarchy the correlation will increase between observations.

The multilevel random effects regression does not assume that each observation is independent, thus it allow for some degree of dependent clustering in the observations. Furthermore, the explanatory variables in our model vary only at the level of firm, while the dependent variable is at the lower product-level. We use white's general test[8] and Wooldridge test[9] to test for heteroskedasticity and autocorrelation in the error terms for all regressions; both tests reject the null hypothesis i.e. we have heteroskedasticity and autocorrelation. However, by applying cluster robust inference we are able to achieve standard errors robust to heteroskedasticity and autocorrelation.

[8] Using the stata comand whitetst.

[9] Using the stata comman xtserial.

In order to investigate whether we should treat the unobserved effects as fixed- or random-effects, we performed a version of the Hausman test[10]. This alternative version of the test relaxes the assumptions of homoskedasticity and no autocorrelation in the residuals (Schaffer et al., 2006). The null-hypothesis is equivalent to that of the regular Hausman test; that the regressors are not correlated with the unobserved effects. If the estimates are not systematically different from each other, the null- hypothesis is not rejected and the random effects estimator is most efficient. In our case we are interested in a time-invariant regressor ($X^h_{1j}$). Therefore, applying the within estimator, which will remove this regressor from the equation is not a particurly good option. The two approaches we have taken thus allow for time-invariant regressors.

We performed the alternative Hausman test on the different regressions for the complete sample and the sub-samples used in the various regressions. Equivalently to the Hausman test, the test statistic is $\chi^2(11)$ under the null- hypothesis. For the whole sample, we find that the null hypothesis is not rejected with test- statistics: 15.46, 10.77 and 13.16, for the regressions with investment spike regressors, positive labour spike regressors and negative labour spike regressors, respectively. This means that the estimated $\beta$'s are very similar whether you use fixed or random effects, and random effects estimation is the most efficient approach.

When dividing the sample into product groups we find that some of the regressions are not satisfying the assumption of the random effects regression. Especially, using data from product group 4 and 5, all regressions rejected the null hypothesis. To account for this failure of assumptions, we apply the correlated random effects approach. This method allows the unobserved effects to be correlated with the average of the regressors and therefore corrects the violation of assumptions (Wooldridge, 2013). Thus, we can model the unobserved effects as (Wooldridge, 2013):

$$\zeta^{(j)} = \pi + \varphi \overline{\boldsymbol{X}}_{t,j} + r_{t,j}$$

Here, $\overline{\boldsymbol{X}}_{t,j}$ is a vector of the within- firm averages of the regressors, and $r_{t,j}$ is an error component. We further assume that $cov(\overline{\boldsymbol{X}}_{t,j}, r_{t,j}) = 0$.

[10] Using Stata command xtoverid.

Applying the correlated random effects, the new regression specifications is therefore:

$$\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)_{t,i} = \beta_1 \left(X_1^h\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^h\right)_{t,j} + \eta + \pi + \varphi \overline{\boldsymbol{X}}_{t,j} + r_{t,j} + \epsilon_{t,i}$$

This is essentially a fixed effects model, and the results are therefore very similar to the LSDV estimates. We have indicated the regressions where we have used this approach with CRE*.

We have regressions with dummy variables indicating one year before a spike, continually going forward to indicating more than two years after a spike. Until now we have only removed firms with less than three years of contiguous data. This may theoretically constitute a problem if the reason for not achieving all regressors equal to unity for a given product is correlated with the regressors. This may happen if there was a specific incident that led to discontinuation of the product or to a spike late in the observed sequence. For all the regressors to be equal to unity for one firm over the observed period we need at least 6 years of contiguous data. Remember that from our construction of the regressand as a relative change, we lose the first observation. If we remove firms with less than 6 years of contiguous observations we lose more than 3, 500 observations. Performing this measure yields very similar results.

# 6. Empirical Results

The following tables display the estimated values of the parameter vectors $\beta_k^h$, $k = 1, ..., 6$, for the total sample and the five product groups for the model described in the previous section. The estimated coefficients show the effect of factor spikes on firms' price setting behaviour and can be interpreted as the estimated change in price change around a spike. We present both LSDV estimates and mixed effects estimates. The choice of estimation method does not change the estimates significantly, thus increasing the robustness of our paper. The discussion of the results proceeds as follows. First, we discuss the effect of capital investments on price changes; then we take a closer look at and discuss the effects of adjustments in the labour stock; next we divide the sample into industry sectors to see if this has any impact on the results; finally we turn the equation around in order to take a closer look at the effect of price spikes on the factor adjustments.

***Table 4*** *- Effect of factor adjustments on price changes (total sample)*

| | **Capital investment** | | **Positive labour spike** | | **Negative labour spike** | |
|---|---|---|---|---|---|---|
| | LSDV | Mixed model | LSDV | Mixed model | LSDV | Mixed model |
| **> 0 spikes** | **-0.005** | **-0.005** | **-0.018** | **-0.012*** | **0.003** | **0.005** |
| | (0.014) | (0.007) | (0.011) | (0.007) | (0.006) | (0.006) |
| **Current** | **0.004** | **0.002** | **0.018*** | **0.018**** | **-0.015** | **-0.014** |
| | (0.010) | (0.009) | (0.009) | (0.008) | (0.010) | (0.009) |
| **Previous** | **0.018** | **0.015** | **0.014** | **0.014** | **-0.019*** | **-0.017*** |
| | (0.014) | (0.012) | (0.010) | (0.009) | (0.011) | (0.009) |
| **2 years previous** | **-0.002** | **-0.007** | **0.008** | **0.009** | **0.001** | **0.003** |
| | (0.013) | (0.011) | (0.012) | (0.011) | (0.011) | (0.010) |
| **> 2 years previous** | **0.018** | **0.013** | **0.018** | **0.019*** | **-0.007** | **-0.004** |
| | (0.013) | (0.010) | (0.012) | (0.011) | (0.011) | (0.009) |
| **Next** | **0.007** | **0.006** | **0.002** | **0.003** | **-0.005** | **-0.005** |
| | (0.010) | (0.009) | (0.009) | (0.009) | (0.010) | (0.009) |
| CRE* | | | | | | |
| Time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm dummies | Yes | | Yes | | Yes | |
| N | 5372 | 5372 | 5579 | 5579 | 5579 | 5579 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*
*CRE is the Correlated Random Effects Approach (see discussion of methods)*

***Table 5*** *- Effect of factor spikes on price change (Intermediate goods)*

| | Capital investment | | Positive labour spike | | Negative labour spike | |
|---|---|---|---|---|---|---|
| | LSDV | Mixed model | LSDV | Mixed model | LSDV | Mixed model |
| **> 0 spikes** | **-0.005** | **0.001** | **-0.014** | **-0.010** | **-0.002** | **-0.003** |
| | (0.026) | (0.010) | (0.013) | (0.010) | (0.009) | (0.008) |
| **Current** | **0.012** | **0.009** | **0.025*** | **0.026*** | **-0.022*** | **-0.019*** |
| | (0.015) | (0.013) | (0.015) | (0.013) | (0.013) | (0.012) |
| **Previous** | **0.014** | **0.008** | **0.025** | **0.027*** | **-0.017** | **-0.013** |
| | (0.014) | (0.012) | (0.016) | (0.015) | (0.016) | (0.013) |
| **2 years** | **0.002** | **-0.005** | **0.005** | **0.008** | **0.006** | **0.012** |
| **previous** | (0.017) | (0.013) | (0.015) | (0.013) | (0.016) | (0.014) |
| **>2 years** | **0.027** | **0.018** | **0.027** | **0.032*** | **-0.000** | **0.007** |
| **previous** | (0.017) | (0.013) | (0.017) | (0.017) | (0.017) | (0.013) |
| **Next** | **0.010** | **0.008** | **0.011** | **0.011** | **0.009** | **0.010** |
| | (0.016) | (0.015) | (0.014) | (0.013) | (0.015) | (0.014) |
| CRE* | | | | | | |
| Time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm dummies | Yes | | Yes | | Yes | |
| N | 2756 | 2756 | 2821 | 2821 | 2821 | 2821 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*
*CRE is the Correlated Random Effects Approach (see discussion of methods)*

***Table 6*** *- Effect of factor spikes on price change (capital goods)*

| | Capital investment | | Positive labour spike | | Negative labour spike | |
|---|---|---|---|---|---|---|
| | LSDV | Mixed model | LSDV | Mixed model | LSDV | Mixed model |
| **> 0 spikes** | **0.004** | **0.007** | **0.003** | **0.001** | **0.013** | **0.013** |
| | (0.010) | (0.009) | (0.011) | (0.009) | (0.013) | (0.013) |
| **Current** | **0.003** | **-0.001** | **-0.003** | **-0.007** | **-0.021** | **-0.023** |
| | (0.019) | (0.018) | (0.012) | (0.013) | (0.028) | (0.027) |
| **Previous** | **0.009** | **0.004** | **-0.019*** | **-0.024***** | **-0.026** | **-0.027** |
| | (0.031) | (0.030) | (0.010) | (0.009) | (0.024) | (0.023) |
| **2 years** | **0.010** | **0.003** | **0.014** | **0.010** | **0.006** | **0.003** |
| **previous** | (0.021) | (0.020) | (0.022) | (0.022) | (0.034) | (0.033) |
| **> 2 years** | **0.026** | **0.018** | **-0.029** | **-0.035** | **-0.026*** | **-0.029**** |
| **previous** | (0.031) | (0.028) | (0.026) | (0.022) | (0.013) | (0.012) |
| **Next** | **0.020** | **0.016** | **-0.005** | **-0.006** | **-0.040**** | **-0.039***** |
| | (0.017) | (0.016) | (0.016) | (0.016) | (0.015) | (0.014) |
| CRE* | | Yes | | | | Yes |
| Time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm dummies | Yes | | Yes | | Yes | |
| N | 785 | 785 | 812 | 812 | 812 | 812 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*
*CRE is the Correlated Random Effects Approach (see discussion of methods)*

***Table** 7 - Effect of factor spikes on price change (durables)*

| | Capital investment | | Positive labour spike | | Negative labour spike | |
|---|---|---|---|---|---|---|
| | LSDV | Mixed model | LSDV | Mixed model | LSDV | Mixed model |
| **> 0 spikes** | **-0.152** | **-0.155*** | **-0.031** | **-0.032*** | **-0.003** | **-0.004** |
| | (0.089) | (0.087) | (0.018) | (0.017) | (0.015) | (0.014) |
| **Current** | **-0.066*** | **-0.064**** | **-0.001** | **-0.001** | **-0.022** | **-0.021** |
| | (0.033) | (0.032) | (0.020) | (0.020) | (0.021) | (0.020) |
| **Previous** | **0.225**** | **0.227***** | **-0.011** | **-0.012** | **0.004** | **0.003** |
| | (0.085) | (0.083) | (0.014) | (0.013) | (0.016) | (0.015) |
| **2 years** | **0.219**** | **0.222***** | **0.065** | **0.066** | **0.009** | **0.008** |
| **previous** | (0.084) | (0.082) | (0.053) | (0.051) | (0.012) | (0.011) |
| **> 2 years** | **0.199**** | **0.203**** | **0.021** | **0.022** | **0.044**** | **0.044***** |
| **previous** | (0.085) | (0.083) | (0.023) | (0.021) | (0.016) | (0.015) |
| **Next** | **-0.081** | **-0.080*** | **-0.047***** | **-0.045***** | **-0.018** | **-0.019*** |
| | (0.048) | (0.046) | (0.014) | (0.013) | (0.011) | (0.011) |
| CRE* | | Yes | | Yes | | Yes |
| Time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm dummies | Yes | | Yes | | Yes | |
| N | 457 | 457 | 464 | 464 | 464 | 464 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*
*CRE is the Correlated Random Effects Approach (see discussion of methods)*

***Table 8** - Effect of factor spikes on price change (non-durables, non-food)*

| | Capital investment | | Positive labour spike | | Negative labour spike | |
|---|---|---|---|---|---|---|
| | LSDV | Mixed model | LSDV | Mixed model | LSDV | Mixed model |
| **> 0 spikes** | **-0.006** | **0.002** | **-0.016** | **-0.016** | **0.007** | **0.008** |
| | (0.022) | (0.020) | (0.018) | (0.017) | (0.012) | (0.012) |
| **Current** | **-0.022** | **-0.026*** | **0.034** | **0.034** | **-0.018** | **-0.019** |
| | (0.015) | (0.014) | (0.025) | (0.024) | (0.014) | (0.013) |
| **Previous** | **-0.008** | **-0.013** | **0.019** | **0.019** | **-0.010** | **-0.011** |
| | (0.026) | (0.024) | (0.015) | (0.014) | (0.022) | (0.020) |
| **2 years** | **-0.011** | **-0.017** | **-0.003** | **-0.004** | **-0.020** | **-0.019** |
| **previous** | (0.016) | (0.016) | (0.012) | (0.012) | (0.015) | (0.015) |
| **> 2 years** | **-0.002** | **-0.011** | **0.059*** | **0.057*** | **-0.014** | **-0.014** |
| **previous** | (0.018) | (0.017) | (0.034) | (0.032) | (0.018) | (0.017) |
| **Next** | **-0.009** | **-0.012** | **0.004** | **0.005** | **-0.002** | **-0.004** |
| | (0.012) | (0.012) | (0.022) | (0.021) | (0.009) | (0.009) |
| CRE* | | Yes | | Yes | | Yes |
| Time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm dummies | Yes | | Yes | | Yes | |
| N | 425 | 425 | 452 | 452 | 452 | 452 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*
*CRE is the Correlated Random Effects Approach (see discussion of methods)*

***Table 9*** *- Effect of factor spikes on price change (non-durables, food)*

| | Capital investment | | Positive labour spike | | Negative labour spike | |
|---|---|---|---|---|---|---|
| | LSDV | Mixed model | LSDV | Mixed model | LSDV | Mixed model |
| **> 0 spikes** | **0.018** | **0.015** | **-0.004** | **-0.006** | **-0.006** | **-0.006** |
| | (0.022) | (0.021) | (0.025) | (0.022) | (0.010) | (0.010) |
| **Current** | **-0.005** | **-0.002** | **-0.006** | **-0.004** | **0.047*** | **0.047**** |
| | (0.023) | (0.022) | (0.021) | (0.020) | (0.024) | (0.023) |
| **Previous** | **0.001** | **0.003** | **0.012** | **0.013** | **0.016** | **0.017** |
| | (0.021) | (0.019) | (0.018) | (0.017) | (0.024) | (0.023) |
| **2 years** | **-0.057*** | **-0.054*** | **-0.026*** | **-0.023*** | **0.002** | **0.002** |
| **previous** | (0.030) | (0.029) | (0.014) | (0.014) | (0.014) | (0.014) |
| **> 2 years** | **-0.031** | **-0.027** | **-0.011** | **-0.008** | **0.010** | **0.011** |
| **previous** | (0.022) | (0.020) | (0.018) | (0.018) | (0.028) | (0.027) |
| **Next** | **-0.002** | **-0.001** | **-0.015** | **-0.012** | **0.003** | **0.002** |
| | (0.018) | (0.017) | (0.017) | (0.017) | (0.024) | (0.023) |
| CRE* | | Yes | | Yes | | Yes |
| Time dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm dummies | Yes | | Yes | | Yes | |
| N | 949 | 949 | 1030 | 1030 | 1030 | 1030 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*
*CRE is the Correlated Random Effects Approach (see discussion of methods)*

## 6.1 Capital investments

From the tables above, the effects of capital investment on price changes are very limited. With a few exceptions, only firms producing durables seems to have a significant relationship between the two events. Here, close to all estimates are significant both using LSDV and the mixed effects model. Firms that experience an investment spike during the sample period seem to have a strategy of smaller price changes than firms that don’t invest. The estimates indicate that a firm that produces durables (domestic appliances, television and radio, furniture and photographic instruments), on average reduce their prices in the same year as the investment, but increases the price change sharply the following two years. The reduction in price-change the year before and in the same year as the investment can possibly be explained by strong market competition. These products have over the course from 2002 to 2009 become cheaper and easier available from producers in low cost countries like China (SSB, 2009). At the same time 2004-2008 was characterized by economic expansion and high demand, which can partly justify the sharp increase in average prices. Furthermore, it is also likely that diversifying or new technology can explain these findings. The relationship must not be stressed too much, as this product group only represent 8% of the total dataset on manufacturing industry in Norway.

The other products groups, however, do not seem to have a relationship between investment spikes and price change. Possible explanations for this can be firm-specific conditions such as long-term customer relations or financial constrains, as suggested in Lundin et al. (2009). Long-term customer relations are listed as the main reasons for sticky prices (Álvarez et al., 2006), which include specified contracts that make the firms restricted to price adjustments. The firms are therefore constrained from adjusting prices to finance the investment. This seems reasonable for intermediate goods and can be an explanation of the non-existing significant relationship between investments in capital and price adjustments. The other product groups are however not goods bought on a regular basis and price contracts are therefore seldom. As we just discussed, the long-term customer relations argument does not explain our lack of a significant relationship between the firms' investment and price adjustments other than for intermediate goods.

When taking the degree of market competition into consideration, the results may indicate that that the firms operate in highly competitive markets. That is, they cannot change their prices in accordance to idiosyncratic conditions.

In our dataset the correlation between investment rates and price changes is only 3.8% and our non-significant estimates stands in contrast to Lundin et al. (2009), who find strong significant coefficients for investment on price change. Although, the model presented by Lundin et al. and our model are not completely comparable, as they do not look explicitly at lumpy investments on price changes, but on the change in capital stock on the relative market price. Nevertheless, the difference in the results is remarkable.

We have so far included all investments in the range [-0.5, 2]. To test whether outliers are contaminating our results we follow the robustness measure of Letterie et al. (2004) and remove investment observations above 100%. The rationale behind performing this measure is to reduce the prevalence of outliers that might potentially bias the regression estimates. Since our sample is relatively small and the omitted observations are scarce, these observations possibly do not represent common factor adjustments. This measure does not significantly change the estimates or standard errors.

## 6.2 Episodes of large changes in labour stock

As mentioned earlier, Fabiani et al. (2005) state that mark-up pricing is the most common price setting policy by firms. The table 4 shows that large episodes of hiring have a positive relationship with price adjustments; higher wages is associated with higher prices, and lower wages with lower prices[11]. On the total sample, price changes increase by 1.8% in the same period as the hiring episode. In addition, we also see that the $\beta_1^{posL}$ is significant and negative. This indicates that firms experiencing a burst in job creation over the period are likely to decrease their average price change by 1.2 percentage points (mixed effects model). This estimate may reflect the economic growth and competition during the years from 2003 to 2008, with low inflation rates and low unemployment (SSB, 2013) firms hired many people, but could not increase prices in the same fashion. The estimates on negative labour spikes however, do not imply any relationship between firings (or resignations) and price changes.

The total sample points to a significant interrelation between lumpy labour adjustments and price changes. This may indicate that mark-up prices can be a partial description of Norwegian manufacture price strategies. We see however that when we disaggregate the sample into product groups, the relationship between labour spikes and price change seem to lose some of its significance. This may be because some of the product groups are too small as a sample, or that firms within product groups are not particularly homogenous. Thus our results are ambiguous. We only find a few significant estimates, for example; for intermediate goods (the largest group), the estimate for price changes the same year as a labour adjustment spike is significant at the 10% level. Moreover, we find a negative relationship the year after a hiring episode in firms producing capital goods. For negative labour spikes, firms seem to decrease their prices in the year before a reduction in labour stock. Finally, for durables the firms seem to decrease their price changes the year before a

[11] Note however that the estimates do not say anything about causality, which is whether the spikes effect on price change is explained by the model, or by some third factor that affect both price and factor spikes simultaneously, for example business cycles or market competition.

spike in labour hiring. It also seems that negative labour spikes have a long-term effect on prices. Non-durables, both food and non-food, have no significant estimates on the 5% level, except for a positive change in price adjustment in the same year as a negative labour spike for food-producers. Both estimations, LSDV and the mixed effects model, produce very similar estimates. The low degree of significant findings are not surprising as the correlation between change in labour stock and price change is only 3.8%. Overall we can conclude with no or very weak effect of large labour adjustments and price setting changes for the specific product groups. Again, we can point to the plausible explanations of the lack of significant estimates, i.e. firm-specific conditions, such as explicit and implicit customer contracts, financial constraints and low market power.

When looking at the total sample, the findings point to monopolistic competition in the Norwegian manufacturing industry, because firms are to some degree able to adjust their prices in response to idiosyncratic shocks. Monopolistic competition is an important part of the New-Keynesian theory that many western economies are built upon, including Norway. Monetary policy works through the transmission channels of demand, expectation and exchange rates (Norges bank, 20013). Through the demand and expectations channels, firms are likely to increase capital or labour stock in response to an expansionary monetary policy[12]. When the central bank decreases the interest rate, it becomes relatively cheaper to invest in capital. Firms also hire more when they expect future demand to increase. Monetary theory further states that in response to the increased investments and costs of the firm, the prices will increase and thus influence the inflation. From our results it seems that this statement is only true when firms adjust their labour stock and not capital, as labour is more directly connected with output marginal costs. However, the estimates show weak relationships between the labour stock adjustments and prices. This means that the central bank policy´s effect on the inflation through the supply side of the demand channel is not as direct as theory states. Moreover, firms are expected from monetary theory to increase prices in response to increased demand from customers. This relationship is not investigated in this study, but empirically it seems to be weaker than what theory suggests (Gottfries, 1991). In fact, firms may even decrease prices when demand increases. The intuitive reason for this is that firms can then use an aggressive price strategy to increase the customer stock. We do

[12] This is the so-called ”credit-channel” described by Bernanke and Getler (1995)

see some evidence of this in association with labour for capital goods and both labour and capital investments in some of the industry sectors presented later.

## A graphic presentation of results by product group

The following set of graphs presents the results of the factor spikes on price changes by product group, using the mixed effect model estimates. The graphs display the estimated changes in price change in the periods around a spike in either capital investment or labour adjustment. On the horizontal axis *t-1* is the year before the spike ($\beta_1^h + \beta_5^h$), *t* is the year the spike occur ($\beta_1^h + \beta_2^h$), *t+1* and *t+2* is the years after the spike ($\beta_1^h + \beta_3^h$ and $\beta_1^h + \beta_4^h$), and *[t+3≥* denotes the time longer than two years since the last spike ($\beta_1^h + \beta_6^h$).

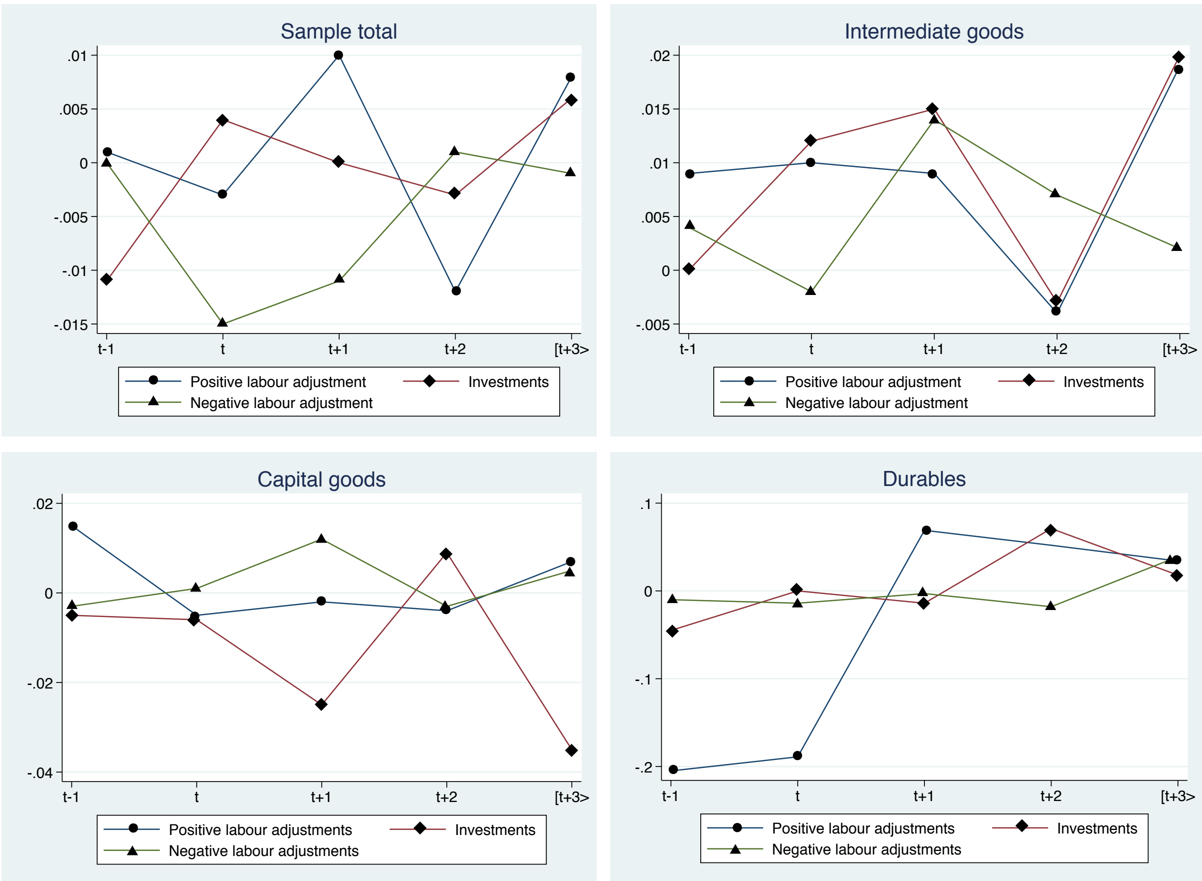


***Fig. 18*** *- Estimated coefficients of investment spikes, positive and negative labour spikes on price changes*

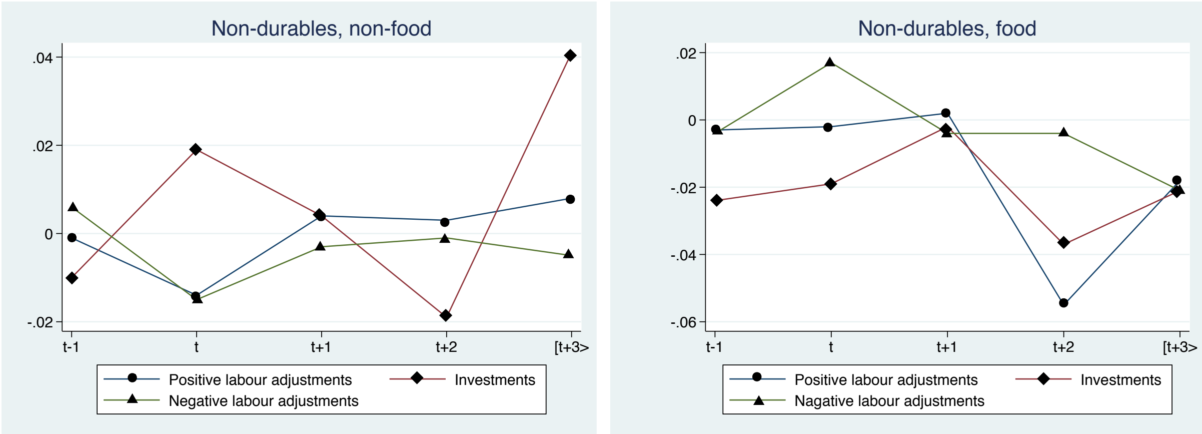


***Fig. 18 (cont.)*** *- Estimated coefficients of investment spikes, positive and negative labour spikes on price changes*

In summary we primarily find small and mainly insignificant effects of lumpy factor adjustments on price change. We have discussed plausible reasons for this, including low market power, implicit and explicit long-term customer contracts and fiscal constraints. Our results are consistent with other theories of price setting behaviour, such as Fabiani et al. (2005), Álvarez et al. (2006), Baudry et al. (2007), Klenow and Kryvtsow (2008) and Nakamura and Steinsson (2008). However, Lundin et al (2009) who do not look specifically at lumpy investments, finds a strong relationship between investments and prices.

## 6.3 Results by industry sectors

Dividing the total sample into subsamples of product groups we were able to find differences in firms that were offering similar or substitute goods. Another way to disaggregate the total sample is by industry sector. There is reason to believe that firms within a given sector behave similarly when it comes to decisions about factor investments and price setting. The model is therefore estimated using mixed model by two-digit SIC industry codes. Results are presented in appendix 3.

The first we find is that the relationship between lumpy investments and price changes are clearly apparent in some sectors, while non-existing in others. The sectors that do seem to have a strong relationship between factor investments to the change in price setting behaviour is SIC 17 (manufacture of textiles), SIC 18 (manufacture of wearing apparel), SIC

20 (manufacture of wood and wood products), SIC 26 (manufacture of non-metallic mineral products), SIC 31 (manufacture of electrical and optical equipment), SIC 32 (manufacture of radio, TV and communication equipment and apparatus), SIC 33 (Manufacture of medical, precision and optical instruments, watches and clocks), SIC 36 (manufacture of furniture). All industries, but SIC 26, are in the production of complex goods that are assembled by a diversity of parts. We would therefore expect the prices of these goods to be relatively more sensitive to changes in marginal costs. Moreover, the producers in these sectors are able to diversify themselves from others based on quality and design, as apposed to many of the other sectors. Firms in these sectors may therefore be able to adjust prices more freely to their profile of cost. We see from the estimates that some are negative while others are positive, which may reflect the different degrees of competition in the various markets where lowering prices increases market share, but may decrease profitability.

Second, we find that investment spikes in capital, but not labour, significantly affect several sectors (SIC 17, SIC 18 and SIC 33). Other sectors have significant relationship between labour adjustments, but not with investment in capital (SIC 14, SIC 20, SIC 28, SIC31 and SIC 32). Apparently, it does not matter whether the sector is labour intensive or not. The duration of the effect differs somewhat and several sectors exhibit a negative relationship between investment in capital and change in price change in the same period and in the period after the spike. This negative effect may suggest strong degree of competition in the various markets.

Third, SIC 15 (manufacture of food and beverages), SIC 24 (manufacture of chemicals and chemical products), SIC 25 (manufacture of rubber and plastic products), and SIC 29 (manufacture of machinery and equipment) have all close to no significant estimates. This suggests that the firms in these sectors do not change their prices in events of lumpy factor adjustments.

Finally, some of sectors do not experience any spikes during the sample period. Excluding these sectors from the total sample, do not change the results of weak or no relationship between factor investments and price adjustments presented in the previous section.

Economic theory suggests that as the firm’s costs change, the prices are likely to change accordingly. Whether the mark-up increases, stays the same or decreases, depends on the firms liquidity constrains, the firm’s market share and the degree of competition in the market. As we have seen, the interrelation between price changes and lumpy factor adjustments differs in various industry sectors. Without a thorough investigation of the firms' condition of liquidity, market share and the market competition and demand, we are not able to make any statements whether the theory is matching the data or not.

## 6.4 Alternative regressions with price spike regressors

There may potentially exist a relationship in the opposite direction where the factor adjustment rates are affected by spikes in price adjustment. To investigate this possibility, we turn the regressions around so that the main regressors price spikes. The dependent variable in these regressions is therefore the factor adjustment rates, as presented below. The definition of a spike follows the method used for defining spikes in the labour adjustment rate. Furthermore, the regressors are created the same way as outlined for the main regressions in section 5.

Turning the regression poses some problems because the price spikes occur at the product-level, whilst the dependent variable is at the higher producer-level. A single firm have more than one associated product, so a firm can have a price spike in more than one product. The dataset was therefore collapsed to construct a model were all variables are at the producer-level. A spike in the price adjustment of one or more products for a single year is therefore only registered as one spike in that year.

For this approach we create a regression only for the total sample. Since the variables in the regression are all on the producer-level, we simplify the estimation method and apply a random effects model, with sector and time dummies. Furthermore, the standard errors are made robust to heteroskedasticity. The theoretizised relationship between price spikes and factor adjustment rates is expressed with the following equations:

$$\left(\frac{I_t}{K_{t-1}}\right)_{t,j} = \beta_1\left(X_1^p\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^p\right)_{j,t} + \zeta^{(j)} + \eta + \zeta^{(k)} + \epsilon_{t,j}$$

$$\left(\frac{\Delta L_t}{L_{t-1}}\right)_{t,j} = \beta_1\left(X_1^p\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^p\right)_{j,t} + \zeta^{(j)} + \eta + \zeta^{(k)} + \epsilon_{t,j}$$

In these equations, $I_t$ denotes capital investment in absolute terms, whilst $L_t$ is the labour adjustment rate. The $\zeta^{(j)}$ term represents the random effects, $\zeta^{(k)}$ represents the sector-dummies, $\eta$ are time- dummies, and $\epsilon_{t,j}$ is the idiosyncratic error.

We performed the regular Hausman test to test whether using random effects is valid. The test-statistic is: $H = (\hat{\beta}_{RE} - \hat{\beta}_{FE})'W(\hat{\beta}_{RE} - \hat{\beta}_{FE}).$ Under the null- hypothesis of no systematic differences in coefficents between the random effects and fixed effects approach, the test statistic is $\chi^2(11)$. We get the values: 13.32 and 6.83 for the regressions of the capital investment rate with respectively positive and negative price spike regressors. For the regressions of the labour adjustment rate we get: 12.76, and 9.61, with positive and negative regressors, respectively. Based on these results, using random effects is therefore warranted.

## Results from regressions of the factor adjustments rates on price spikes

Looking at table 10 we see that there are no significant coefficients in the estimated model where we have regressed the factor adjustment rates on the positive price-spike dummies. This might seem surprising since we have established a positive relationship between spikes in the labour-adjustment rate and price changes. But, remember that according to the definition, a spike constitutes a rare episode, and is therefore not related to the normal rate of adjustment. The increased price change rate, which is related to the spike in labour adjustment, need therefore not represent spikes in the price.

Table 11 presents the two regressions with negative price spike regressors. In this table, we see that there are several significant coefficients. From the results it seems there is strong evidence that firms, which have experienced a negative price spike, have on average a higher adjustment rate for both capital and labour. Additionally, the labour adjustment rate seems to decrease in the periods before and after a spike by about 5 percentage points. The investment rate decrease according to the estimates by on average 4.2 percentage points in the period two years after a price spike, and continues to decrease by on average 6.4 percentage points in the following years.

These results indicate that negative price spikes have a more fundamental effect on the dynamics of firm- level factor adjustments than positive spikes. Additionally, firms seem to adjust the labour adjustment rate in the two periods surrounding a negative spike, but the investment rate is only adjusted after the price spike. This may indicate that the hiring rate is more flexible, and therefore represents the first line of adjustment.

***Table 10** – Effect of positive price spikes on factor adjustments (total sample)*

| _ | Capital investment | Labour adjustment |
|---|---|---|
| **> 0 spikes** | **-0,012** | **-0,009** |
| | (0.009) | (0.011) |
| **Current** | **0,006** | **0,022** |
| | (0.011) | (0.013) |
| **Previous** | **0,016** | **-0,017** |
| | (0.015) | (0.014) |
| **2 years previous** | **0,018** | **0,011** |
| | (0.022) | (0.019) |
| **> 2 years previous** | **-0,003** | **0,017** |
| | (0.019) | (0.021) |
| **Next** | **0,016** | **0,001** |
| | (0.012) | (0.012) |
| Time dummies | Yes | Yes |
| Sector dummies | Yes | Yes |
| N | 1871 | 1614 |
| # of individual spikes | 274 | 280 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*

***Table 11** – Effect of negative price spikes on factor adjustments (total sample)*

| _ | Capital investment | Labor adjustment |
|---|---|---|
| **> 0 spikes** | **0.026*** | **0.038**** |
| | (0.014) | (0.015) |
| **Current** | **-0,004** | **-0,018** |
| | (0.019) | (0.022) |
| **Previous** | **-0,027** | **-0.052**** |
| | (0.016) | (0.025) |
| **2 years previous** | **-0.042**** | **-0,032** |
| | (0.019) | (0.021) |
| **> 2 years previous** | **-0.064***** | **-0,02** |
| | (0.019) | (0.022) |
| **Next** | **0,011** | **-0.050**** |
| | (0.019) | (0.023) |
| Time dummies | Yes | Yes |
| Sector dummies | Yes | Yes |
| N | 1871 | 1614 |
| # of individual spikes | 98 | 108 |

*Note: Standard errors are reported in parentheses. Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*

# 7. Relationship Between Capital and Labour Adjustments

When studying the dynamics of plant-level variables most papers have treated lumpy investments in capital, adjustments in labour and productivity changes, as isolated events (Sakellaris, 2004). This approach reduces the complexity, but newer studies have found evidence of a prevalent interrelationship between adjustments in input factors and resulting dynamics of other plant level variables. It is therefore interesting to see how this finding applies to our sample of observations, as this may also affect other firm level decisions, such as pricing.

Two papers that have explicitly researched the interrelation between input factors are Letterie et al. (2004) for the Dutch manufacturing industry, and Leitner (2008) for Austrian manufacturing. Their results are similar with a strong intertemporal relationship of a spike in one factor and the adjustment of the other. Additionally, Sakellaris (2004), Nilsen et al. (2009) and Grazzi et al. (2013) also find that the demand for the two production factors is strongly interrelated.

Following Letterie et al. (2004) we perform a descriptive investigation of the dynamic relationship between lumpy capital adjustments and labour adjustments, and conversely, the relationship between lumpy labour adjustments and capital adjustments. Our results are comparable to the results of Letterie et al (2004), as can be seen from table 12 and 13.

Where Letterie et al. (2004) used a first differenced regression model to account for the unobserved firm-level effects, we employ a random effects model. To account for higher-level unobserved effects we include sector-dummies, in addition to time-dummies. We employ the same vector of covariates described in the methodology (section 5). The econometric models used for this investigation are:

$$\left(\frac{I_t}{K_{t-1}}\right)_{t,j} = \gamma\left(X_1^l\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^l\right)_{t,j} + \zeta^{(j)} + \eta + \zeta^{(k)} + \epsilon_{t,j}$$

$$\left(\frac{\Delta L_t}{L_{t-1}}\right)_{t,j} = \beta_1\left(X_1^i\right)_j + \sum_{k=2}^{6} \beta_k \left(X_k^i\right)_{t,j} + \zeta^{(j)} + \eta + \zeta^{(k)} + \epsilon_{t,j}$$

In these equations, $I_t$ denotes capital investment, whilst $L_t$ is the labour adjustment rate. The $\zeta^{(j)}$ term represents the random effects, $\zeta^{(k)}$ represents the sector- dummies, and $\eta$ are time-dummies.

Letterie et al. (2004) have analysed data consisting of a balanced panel, and it is perhaps therefore that their estimates have less variation than our estimates. To account for heteroskedasticity and serial correlation in our residuals, we use robust standard errors for inference.

***Table 12*** *- Effect of capital investment spikes on labour stock adjustments (total sample)*

| | Our model | Letterie et. al., |
|---|---|---|
| **> 0 Spikes** | **0.033** *** | |
| | (0.011) | |
| **Current** | **0.039** ** | **0.030** *** |
| | (0.018) | (0.005) |
| **Previous** | **-0.003** | **0.011** ** |
| | (0.018) | (0.055) |
| **Two years previous** | **0.002** | |
| | (0.029) | |
| **>Two years previous** | **-0.018** | |
| | (0.016) | |
| **Next** | **0.019** | **0.011** ** |
| | (0.014) | (0.054) |
| Sector Dummies | Yes | |
| Time Dummies | Yes | Yes |
| N | 1874 | |

*Note: Robust standard errors in parentheses.*
*Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*

We see from table 12 that a firm that has experienced at least one burst in capital investment has on average a higher labour adjustment rate. This relationship is not established by Letterie et al. (2004) because they use first differencing. Moreover, according to the results, firms will on average increase their labour adjustment rate by 3.9 percentage points contemporaneously with a spike in investment. Letterie et al. (2004) obtained a similar relationship for the Dutch manufacturing sector, with an average of three percentage points increase in the same year as an investment spike. Their results, however, also indicated a positive relationship in the two surrounding years of an investment spike[13]. We could not find this significant relationship in our dataset.

***Table 13*** *- Effect of labour adjustment spikes on investment (total sample)*

| | Positive Labor Spikes | | Negative Labor Spikes | |
|---|---|---|---|---|
| | Our model | Letterie et.al., | Our model | Letterie et.al., |
| **> 0 Spikes** | **0.002** | | **0.007** | |
| | (0.013) | | (0.011) | |
| **Current** | **0.050***** | **0.031 ***** | **-0.047***** | **-0.027***** |
| | (0.017) | (0.005) | (0.014) | (0.006) |
| **Previous** | **-0.001** | **0.008** | **-0.038***** | **-0.013**** |
| | (0.016) | (0.005) | (0.015) | (0.006) |
| **Two years previous** | **-0,011** | | **-0.014** | |
| | (0.015) | | (0.016) | |
| **> Two years previous** | **0.001** | | **-0.029** | |
| | (0.020) | | (0.024) | |
| **Next** | **0.006** | **0.007** | **-0.015** | **-0.011** |
| | (0.012) | (0.055) | (0.012) | (0.007) |
| Sector Dummies | Yes | | Yes | |
| Time Dummies | Yes | Yes | Yes | Yes |
| N | 1874 | | 1874 | |

*Note: Robust standard errors in parentheses.*
*Asterisks indicate significance at 10%, 5% and 1 % level with *, ** and *** respectively.*

From Table 13 we find a significant increase of about five percentage points in the investment rate contemporaneously with a positive spike in the labour adjustment rate.

For the negative labour adjustment spikes we find the opposite relationship with an average decrease of 4.7 percentage points in the concurrent year. Additionally, we have a significant decrease in the investment rate in the year after a negative labour adjustment spike. This indicates that firms which have been forced to lay-off many employees in one year is set back moving into the next year. However, we cannot find any longer-term effects. As can be seen from table 13, the results obtained by Letterie et al. (2004) are very similar to ours.

Correspondingly to the analysis of Letterie et al. (2004) these results show that the demand for the two production factors is interrelated. Modelling the factor adjustment decision of a firm should therefore account for this result. Asphjell et al. (2010) find that firms should

[13] Although, their point estimates or standard errors must be different from the ones stated. Most likely, the standard errors for these estimates are correct if divided by ten.

invest in capital and labour sequentially, unless there are cost benefits associated with simultaneous adjustment.

We performed the Hausmann test on the regressions to infer whether applying random effects is valid. The Hausmann test statistic $H$: $\chi^2(11)$ yields the values: 4.48, 11.01, and 2.27, for the regressions with investment spike regressors, positive labour spike regressors, and negative labour spike regressors, respectively. Using random effects is therefore valid for all the regressions.

To check the robustness of the estimates, we change the definition of the spikes to the absolute rule. This does not significantly change our results. Moreover, increasing the $\propto$ yields robust results up to 2 for the negative labour spikes, and above 4 for the other regressions.

.

# 8. Summary of Results and Conclusions

Macro models do not primarily take the lumpy nature of factor investments into account. The presence of price rigidities and lumpy factor adjustments of capital and labour in an economy, leads to inefficient market allocation of firms' factor demand and price level choice. By investigating the nature of and dynamics of price adjustments and factor demand, we contribute to develop a better understanding of how the mechanisms in the monetary transmission channels works in Norway. With a better understanding of these dynamics, macro models may be improved to induce greater impact on the economies markets. In this paper we have investigated firms' price setting behaviour in relationship to large episodes of investment in capital and labour. The investigation was conducted using eight years of micro panel data on Norwegian manufacturing plants (VPPI). Our regressions on factor adjustments' effect on price changes find limited evidence correlation between the two. To some degree this contradicts with widespread price setting theory of mark-up pricing over costs of factors, but corresponds to theories on customer contracts and liquidity constraints. However, because of limitations to the dataset we were not able to tests for other considerations that may impact the choice in price settings such as cost of materials, interest rates, customer demand, firm's liquidity, customer contracts, market share, competitors price level and the degree of market competition. We are therefore not able to determine any hard conclusions, but it seems that at least the lumpy nature of investment shares do not considerably affect the change in price setting. The link is thus not non-existent. It seems that labour adjustments have a stronger effect on price changes than investments in capital. Possible reasons for the lack of significant relationships are suggested in other papers, as well as in this. They include long-term implicit and explicit customer price-contracts (e.g. Fabiani et al., 2005), illiquid firms and weak market power (Lundin et al., 2009). As part of our investigation on firms' investments patterns we have also estimated how firms adjust employment level (capital stock) in periods of large investments (labour adjustments), and vice versa. We found that firms often increase their labour stock the same year as they invest in new capital. This does not say anything about causality, but point to the fact that when modelling demand for production factors, the close relationship between labour and capital should be taken into account. The economic implication of the results in this paper is that Norwegian manufacture firms compete in competitive markets where they cannot freely set the prices from idiosyncratic shocks in capital and labour stock. The presence of sticky prices induces money non-neutrality in the short run. This means that monetary shocks has effects on real economy such as inventory and labour, which has further implications for the monetary transmission mechanism. We find however that the interrelations between price changes and lumpy factor adjustments are weak and that this channel must not be emphasised too much when conducting monetary policy.

# 9. References

**Abel, A., & Eberly, J**. (1998). The mix and scale of factors with irrevesibility and fixed costs of investment. *Carnegie Rochester Confrence Series on Public Policy* , 101-135.

**Altinn.** (2013) *Avskrivninger* From ()

**Angeloni, I., Aucremanne, L., Ehrmann, M., Galí, J., Levin, A., & Smets, F.** (2006). New Evidence on Inflation Persistence and Price Stickiness in the Euro Area: Implications for Macro Modeling. *Journal of the European Economic Association* , 562-574.

**Apel, M., Friberg, R., & Hallsten, K**. (2001). *Micro Fundations of Macroeconomic Pric Adjustment: .* Stockholm: Sveriges Riksbank Working Paper Series.

**Asphjell, M. K**. (2013). *Structural Estimation of Price Adjustment Costs Using Micro Level Data.* NHH.

**Asphjell, M. K., Letterie, W., Nilsen, Ø. A., & Pfann, G. A.** (2010). *Sequentiality versus Simultaneity: Interrelated Factor Demand.* Intitue for the Study of Labor (IZA).

**Arrow, K. J., Harris, T., & Marshak, J.** (1951). *Optimal Inventory Policy.* Econometrica.

**Álvarez, L., Dhyne, E., Hoeberichts, M., Kwapil, C., Le Bihan, H., Lünnemann, P., et al.,** (02/2006). Sticky Prices in the Euro Area: a Summary of New Micro Evidence. *Journal of European Economic Research* , 575-584.

**Baudry, L., Bihan, H. L., Sevestre, P., & Tarrieu, S.** (2004). *Price Rigidity: Evidence from the French CPI Macro-Data.* Banque de France Working Paper.

**Baudry, L., Le Bihan, H., Sevestre, P., & Tarrieu, S.** (2007). What do Thirteen Million Price Records have to Say about Consumer Price Rigidity? *Oxford Bulletin of Economics and Statistics* , 139-183.

**Barro, & Barro**, R. J. (1972). A Theory of Monopolistic Price Adjustment. *A review if econometric studies* , 17-26.

**Bils, M., & Chang**, Y. (1999). *Understanding how price responds to costs and production.* Working paper, Penn Institue for Economic Research.

**Blinder, A. S.** (1991). Why are Prices Sticky? Preliminary Pesults from an Interview Study. *NBER Working paper* (3646).

**Blinder, A. S.** (1995). On sticky prices: academic theories meet the real world. *Monetary Policy: Studies in Business Cycles* , 117-150.

**Blinder, A. S., Canetti, E. R., Lebow, D. E., & Rudd, J. B.** (1998). *Asking anout prices; A new approach to understanding price stickiness.* Russell Sage Foundation.

**Bratlie, J.** (2013). *Price Adjustment in Norway: An analysis of micro PPI data.* Bergen/Milan: NHH School of Economics.

**Caballero , R., & Engel, E.** (1999). Explaining investment dynamics in US manufacturing: a generalized (S,s) approach. *Econometrica* , 783-826.

**Caballero, R. J., & Engel, E. R.** (2007). *Price Stickiness in Ss Models: New Interpretations on Old Results.* New Haven: Economic Growth Center (EGC), Yale University.

**Caballero, R. J., Engel, E. M., Haltiwanger, J. C., Woodford, M., & Hall, R. E.** (1995). Plant-Level Adjustment and Aggregate investment Dynamics. 1-54.

**Calvo, G. A.** (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary economics 12* , 383-398.

**Carlsson, M., & Skans, O. N**. (2012). Evaluating Microfundataions for Aggregate Price Rigidities: Evidence from Matched Firm-Level Data on Product Prices and Unit Labor Cost. *American Economic Review* , 1571-1595.

**Doms, M., & Dunne, T.** (1998). Capital Adjustment Patterns in Manufacturing Plants. *Review of Economic Dynamics , 1*, 409-429.

**Fabiani, S., Druant, M., Hernando, I., Kwapil, C., Landau, B., Loupias, C., et al.,** (2005). *The Pricing Behaviour of Firms in the Euro Area: New Survey Evidence.* Banque de France.

**Fehr, E., & Tyran, J.-R**. (2001). *Does Money Illusion Matter?* The American Economic Review.

**Gertler, M., & Bernanke, B**. (1995). Inside the Black Box: The Credit Channel of Monetaru Policy Transmission . *JOurnal of Economic Perspectives , 9*, 27-48.

**Gertler, M., & Leahy, J**. (2008). A phillips curve with an Ss foundataion. *Jouranl of Money, Credit and Banking* , 1241-1277.

**Gourio, F., & Kashyap, A. K.** (2007). Investment Spikes: New Facts and a General Equilibrium Exploration. *Journal of Monetary Economics* (54), pp. 1-22.

**Golosov, M., & Lucas, R. E**. (2003). *Menu Costs and Phillips Curves.* Cambridge: National Bureau of Economic Research.

**Gottfries, N.** (1990). Customer Markets, Credit Market Imperfections and Real Price Rigidity. *Economica* , 317-323.

**Grazzi, M., Jacoby, N., & Treibich, T**. (2013). *Dynamics of Investment and Firm Performance: Comparative evidence from manufacturing industries.* Alma Mater Studiorum - Univesità di Bologna, Department of Economics.

**Hall, S., Walsh, M., & Yates, A**. (2000). Are UK companies' prices sticky? *Oxford Economic papers* (52), 425-446.

**Hamermesh, D. S**. (1988). *Labour demand and the structure of adjustment costs.* Cambridge: National Bureau of Economic Reseach.

**Johnston, M. K.** (2009). *Real and Nominal Frictions within the Firm: How Lumpy Investment Matters for Price Adjustment.* Bank of Canada Working Paper.

**Khan, A., & Thomas, J. K.** (2008). Idiosyncratic shocks and the role of nonconvexities in plant and aggregate investment dynamics. *Econometrica, Vol 76, No. 2* , 395-436.

**Klenow, P. J., & Kryvtsov, O**. (2008). State-dependent or time-dependent pricing: does it matter for recent U.S. inflation? *Quarterly Journal of Economics , CXXIII* (3), 863-904.

**Klenow, P. J., & Malin, B. A**. (2010). *Microeconomic Evidence on Price-Stickiness.* Prepared for the Handbook of Monetary Economics.

**Lundin, M., Gottfries, N., Bucht, C., & Lindstöm, T.** (2009). Price and Investment Dynamics: Theory and Plant-Level Data. *Journal of Money, Credit and Banking , 41* (5), 907-934.

**Leitner, S. M**. (2008). *Interrelatedness, Dynamic Factor Adjustment Patterns and Firm Heterogeneity in Austrian Manufacturing.* Johannes Kepler University of Linz 0803, Working Paper, Department of Economics.

**Letterie, W. A., Pfann, G. A., & Polder, J. M**. (2004). Factor adjustment spikes and interrelation: an emperical investigation. *Economic Letters , 85*, 145-150.

**Nakamura, E., & Steinsson, J.** (2008). Five Facts about Prices: a Reevaluation of Menu Cost Models. *Quarterly Journal of Economics* , 1415-1465.

**Nakamura, E., & Steinsson, J.** (2013). *Price rigidity: microeconomic evidence and macroeconomic implications.* Cambridge: NBER Working Papers.

**Nilsen, Ø. A., & Schiantarelli, F.** (2003). Zeroes and Lumps in Investment: Empirical Evidence on Irreversibilities and Non-Convexities . *Review of Economics and Statistics , 85*, 1021-1037.

**Nilsen, Ø. A., Salvanes, K. G., & Schiantarelli, F.** (2007). Employment adjustment, the structure of adjustment costs, and plant size. *European Economic Review* , 577-598.

**Nilsen, Ø. A., Raknerud, A., Rybalka, M., & Skjerpen, T.** (2009). Lumpy investment, factor adjustments, and labour productivity. *Oxford Economic Papers , 61*, 104-127.

**Mankiw, G. N., & Reis, R**. (2002). Sticky Information versus Sticky Prices: A Proposal to Replace the New Keynesisan Phillips Curve. *Quarterly Journal of Economics* , 1295-1328.

**Power, L.** (1998). The Missing Link: Technology, Investment, and Productivity. *The Review of Economics and Statistics , 80*, 300-313.

**Sakellaris, P.** (2004). Patterns of plant adjustment. *Journal of Monetary Economics , 51*, 425-450.

**Schaffer, M.E. & Stillman, S. (**2006), XTOVERID: Stata module to calculate tests of overidentifying restrictions after xtreg, xtivreg, xtivreg2, xthtaylor, *Statistical Software Components S456779*

**Sheshinski, E., & Weiss, Y.** (1977). Inflation and Costs of Price Adjustment. *The review of economic studies* , 287-303.

**SSB**. (2013). *Vareprisindeks for industrinæringene.* From http://www.ssb.no/priser-og-prisindekser/statistikker/vppi/maaned/2013-11-11?fane=om#content

**SSB**. (2009). *Nasjonalregnskap og konjunkturer.* From (http://www.ssb.no/nasjonalregnskap-og-konjunkturer/artikler-og-publikasjoner/fra-kjopefest-til-edruelighet).

**SSB**. (2008). *Standard for næringsgruppering.* From http://www.ssb.no/a/publikasjoner/pdf/nos_d383/nos_d383.pdf

**SSB.** (2013). *Statistikkbanken.* From https://www.ssb.no/statistikkbanken/selectvarval/saveselections.asp

**Rabe Hesketh, S., & Skrondal, A.** (2005). *Multilevel and Longitudinal Modeling Using Stata.* Texas: Statacorp LP.

**Reiter, M., Sveen, T., & Weinke, L.** (Forthcoming). Lumpy investment and state-dependent pricing in general equilibrium. *Journal of Monetary Economics* .

**Reiter, M., Sveen, T., & Weinke, L.** (2012). Lumpy Investments and the Monetary Transmission Mechanism in General Equilibrium. *Journal of Monetary Economics , 54*, 23-36.

**Rotemberg, J.** (2003). Customer Anger at Price Increases, Changes in Frequency of Price Adjustment and Monetary Policy. *Journal of Monetary Economics , 52*, 829-852.

**Rotemberg, J**. (2005). Customer Anger at Price Increases, Changes in Frequency of Price Adjustment and Monetary Policy. *Journal of Monetary Economics , 52*, 829-852.

**Wooldridge, J. M**. (2013). *Introductory Econometrics: A Modern Approach, Fifth International Edition.* Michigan: Cengage Learning.

# 10. Appendix

## Appendix 1: Sectors by industries, 2-digit SIC2002

| 2-digit code | Industrial activity |
|---|---|
| 13 | Mining of metal ores |
| 14 | Other mining and quarrying |
| 15 | Manufacture of food products and beverages |
| 16 | Manufacture of tobacco products |
| 17 | Manufacture of textiles |
| 18 | Manufacture of wearing apparel; dressing and dyeing of fur |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; |
| 21 | Manufacture of pulp, paper and paper products |
| 22 | Publishing, printing and reproduction of recorded media |
| 24 | Manufacture of chemicals and chemical products |
| 25 | Manufacture of rubber and plastic products |
| 26 | Manufacture of other non-metallic mineral products |
| 27 | Manufacture of basic metals |
| 28 | Manufacture of fabricated metal products, except machinery and |
| 29 | Manufacture of machinery and equipment n.e.c. |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. |
| 32 | Manufacture of radio, television and communication equipment and |
| 33 | Manufacture of medical, precision and optical instruments, watches and |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers |
| 35 | Manufacture of other transport equipment |
| 36 | Manufacture of furniture; manufacturing n.e.c. |
| 37 | Recycling |

Note: Industry codes and classifications have been collected from SSB. NACE Rev. 1.1

# Appendix 2: Sectors by product categories, 3-digit SIC2002

| 3-digit industry codes | Industrial activity |
|---|---|
| | **Intermediate goods** |
| 131 | Mining of iron ores |
| 132 | Mining of non-ferrous metal ores, except uranium and thorium ores |
| 142 | Quarrying of sand and clay |
| 143 | Mining of chemical and fertilizer minerals |
| 145 | Other mining and quarrying n.e.c |
| 156 | Manufacture of grain mill products, starches and starch products |
| 157 | Manufacture of prepared animal feeds |
| 171 | Preparation and spinning of textile fibers |
| 172 | Textile weaving |
| 173 | Finishing of textiles |
| 176 | Manufacture of knitted and crocheted fabrics |
| 201 | Sawmilling and planing of wood; impregnation of wood |
| 202 | Manufacture of veneer sheets; manufacture of plywood, laminboard, |
| 203 | Manufacture of builder's carpentry and joinery |
| 204 | Manufacture of wooden containers |
| 211 | Manufacture of pulp, paper, and paperboard |
| 212 | Manufacture of articles of paper and paperboard |
| 241 | Manufacture of basic chemicals |
| 243 | Manufacture of paints, varnishes and similar coatings, printing ink and |
| 246 | Manufacture of other chemical products |
| 251 | Manufacture of rubber products |
| 252 | Manufacture of plastic products |
| 261 | Manufacture of glass and glass products |
| 262 | Manufacture of non-refractory ceramic goods other than for construction |
| 265 | Manufacture of cement, lime and plaster |
| 267 | Cutting, shaping and finishing of ornamental and building stone |
| 268 | Cutting, shaping and finishing of ornamental and building stone |
| 271 | Manufacture of basic iron and steel and of ferro-alloys |
| 274 | Manufacture of basic precious and non-ferrous metals |
| 275 | Casting of metals |
| 285 | Treatment and coating of metals; general mechanical engineering |
| 286 | Manufacture of cutlery, tools and general hardware |
| 287 | Manufacture of other fabricated metal products |
| 312 | Manufacture of electricity distribution and control apparatus |
| 313 | Manufacture of insulated wire and cable |
| 315 | Manufacture of lighting equipment and electric lamps |
| 321 | Manufacture of electronic valves and tubes and other electronic |
| 333 | Manufacture of industrial process control equipment |
| 371 | Recycling of metal and scrap |

| | Capital goods |
|---|---|
| | Manufacture of structural metal products |
| 282 | Manufacture of tanks, reservoirs and containers of metal; manufacture of |
| 291 | Manufacture of machinery for the production and use of mechanical |
| 292 | Manufacture of other general purpose machinery |
| 293 | Manufacture of agricultural and forestry machinery |
| 294 | Manufacture of machine tools |
| 295 | Manufacture of other special purpose machinery |
| 311 | Manufacture of electric motors, generators and transformers |
| 332 | Manufacture of instruments and appliances for measuring, checking, |
| 342 | Manufacture of bodies (coachwork) for motor vehicles; manufacture of |
| 343 | Manufacture of parts and accessories for motor vehicles and their |
| 351 | Building and repairing of ships |

| | Durables |
|---|---|
| 297 | Manufacture of domestic appliances n.e.c |
| 323 | Manufacture of television and radio receivers, sound or video recording |
| 334 | Manufacture of optical instruments and photographic equipment |
| 361 | Manufacture of furniture |
| 362 | Manufacture of jewelry and related articles |

| | Non-durables, non-food |
|---|---|
| 174 | Manufacture of made-up textile articles, except apparel |
| 175 | Manufacture of other textiles |
| 177 | Manufacture of knitted and crocheted articles |
| 182 | Manufacture of other wearing apparel and accessories |
| 191 | Tanning and dressing of leather |
| 193 | Manufacture of footwear |
| 222 | Printing and service activities related to printing |
| 244 | Manufacture of pharmaceuticals, medicinal chemicals and botanical |
| 245 | Manufacture of soap and detergents, cleaning and polishing |
| 364 | Manufacture of sports goods |

| | Non-durables, food |
|---|---|
| 151 | Production, processing and preserving of meat and meat products |
| 152 | Processing and preserving of fish and fish products |
| 153 | Processing and preserving of fruit and vegetables |
| 154 | Manufacture of vegetable and animal oils and fats |
| 155 | Manufacture of dairy products |
| 158 | Manufacture of other food products |
| 159 | Manufacture of beverages |
| 160 | Manufacture of tobacco products |

*Note: The SIC2002 classification is base don NACE Rev1.1. The table is obtained from Bratlie (2013)*

# Appendix 3: Effect of factor spikes on price changes by industry sectors, SIC2002

| Sector | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|
| **Investments** | | | | | | | |
| > 0 spikes | . | 0.029 | -0.001 | . | 0.017*** | 0.061 | -0.025 |
| | . | . | (0.015) | . | (0.006) | (0.074) | (0.017) |
| Current | . | 0.191 | -0.000 | . | -0.079*** | 0.009 | 0.022 |
| | . | . | (0.021) | . | (0.029) | (0.006) | (0.017) |
| Previous | . | -0.069 | 0.004 | . | -0.049*** | 0.081*** | -0.001 |
| | . | (0.000) | (0.016) | . | (0.015) | (0.022) | (0.006) |
| 2 years | . | 0.043 | -0.052* | . | 0.024** | -0.167*** | 0.025 |
| previous | . | . | (0.029) | . | (0.012) | (0.024) | (0.017) |
| > 2 year | . | 0.010 | -0.000 | . | -0.002 | -0.044 | . |
| previous | . | . | (0.017) | . | (0.009) | (0.046) | . |
| Next | . | -0.041 | -0.017 | . | . | . | . |
| | . | (0.000) | (0.016) | . | . | . | . |
| **Positive labour spikes** | | | | | | | |
| > 0 spikes | . | 0.012 | -0.010 | . | -0.022** | -0.002 | -0.030 |
| | . | (0.031) | (0.016) | . | (0.010) | (0.023) | (0.000) |
| Current | . | 0.028*** | -0.009 | . | 0.045 | 0.017 | 0.035 |
| | . | (0.010) | (0.019) | . | (0.034) | (0.011) | . |
| Previous | . | -0.005 | 0.009 | . | 0.002 | 0.024 | 0.031 |
| | . | (0.020) | (0.018) | . | (0.025) | (0.021) | . |
| 2 years | . | -0.048*** | -0.026* | . | -0.008 | 0.030 | 0.034 |
| previous | . | (0.016) | (0.014) | . | (0.015) | (0.024) | . |
| > 2 year | . | 0.017 | -0.013 | . | 0.033 | -0.031 | . |
| previous | . | (0.035) | (0.017) | . | (0.023) | (0.033) | . |
| Next | . | -0.058* | -0.009 | . | -0.023 | . | . |
| | . | (0.031) | (0.017) | . | (0.039) | . | . |
| **Negative labour spikes** | | | | | | | |
| > 0 spikes | -0.005*** | 0.012 | -0.004 | . | -0.011 | 0.005 | -0.045*** |
| | (0.000) | (0.030) | (0.013) | . | (0.010) | (0.030) | (0.010) |
| Current | -0.146*** | -0.041 | 0.039* | . | 0.003 | -0.026 | 0.011 |
| | (0.000) | (0.031) | (0.021) | . | (0.016) | (0.017) | (0.019) |
| Previous | . | -0.044 | 0.009 | . | 0.034 | 0.020 | 0.056*** |
| | . | (0.041) | (0.022) | . | (0.026) | (0.064) | (0.010) |
| 2 years | . | 0.210*** | -0.004 | . | 0.028 | -0.013 | . |
| previous | . | (0.030) | (0.016) | . | (0.024) | (0.026) | . |
| > 2 year | -0.054*** | -0.046 | -0.002 | . | 0.027** | -0.032*** | 0.020*** |
| previous | (0.000) | (0.044) | (0.021) | . | (0.011) | (0.012) | (0.004) |
| Next | . | -0.006 | 0.008 | . | 0.059** | -0.014 | . |
| | . | (0.027) | (0.024) | . | (0.026) | (0.026) | . |
| N | 14 | 75 | 972 | 14 | 225 | 115 | 18 |

| Sector | 20 | 21 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| | | | **Investments** | | | | |
| **> 0 spikes** | **0.008** | **.** | **0.043** | **-0.015** | **0.030**** | **0.055** | **0.038***** |
| | (0.020) | . | (0.032) | (0.014) | (0.014) | (0.067) | (0.008) |
| **Current** | **0.040** | **.** | **-0.062*** | **0.007** | **-0.035***** | **-0.062** | **-0.006** |
| | (0.033) | . | (0.033) | (0.015) | (0.012) | (0.103) | (0.023) |
| **Previous** | **0.011** | **.** | **-0.076*** | **-0.012** | **-0.021** | **-0.121** | **-0.002** |
| | (0.019) | . | (0.041) | (0.010) | (0.025) | (0.081) | (0.010) |
| **2 years** | **-0.029** | **.** | **-0.025** | **0.018** | **-0.029*** | **-0.148**** | **-0.043***** |
| **previous** | (0.021) | . | (0.038) | (0.023) | (0.017) | (0.073) | (0.015) |
| **> 2 year** | **-0.035** | **.** | **-0.031*** | **0.025**** | **-0.016** | **.** | **0.002** |
| **previous** | (0.027) | . | (0.017) | (0.012) | (0.012) | . | (0.010) |
| **Next** | **0.022** | **.** | **-0.073**** | **0.011** | **-0.055*** | **.** | **-0.015** |
| | (0.024) | . | (0.036) | (0.015) | (0.031) | . | (0.015) |
| | | | **Positive labour spikes** | | | | |
| **> 0 spikes** | **-0.025** | **0.010** | **-0.011** | **-0.020** | **-0.047***** | **0.230** | **-0.003** |
| | (0.020) | (0.012) | (0.025) | (0.016) | (0.015) | (0.147) | (0.013) |
| **Current** | **0.087*** | **0.003** | **-0.000** | **0.012** | **0.043***** | **-0.289**** | **0.007** |
| | (0.045) | (0.032) | (0.022) | (0.013) | (0.012) | (0.125) | (0.015) |
| **Previous** | **-0.013** | **0.012** | **0.017** | **0.005** | **0.054***** | **-0.220** | **-0.013** |
| | (0.031) | (0.016) | (0.015) | (0.023) | (0.015) | (0.143) | (0.020) |
| **2 years** | **0.081**** | **-0.030**** | **0.036**** | **0.010** | **0.031***** | **-0.320*** | **-0.026** |
| **previous** | (0.036) | (0.013) | (0.015) | (0.016) | (0.011) | (0.170) | (0.023) |
| **> 2 year** | **0.076***** | **-0.032** | **0.037** | **-0.002** | **0.055***** | **0.241** | **-0.023**** |
| **previous** | (0.027) | (0.025) | (0.031) | (0.017) | (0.016) | (0.436) | (0.011) |
| **Next** | **0.088***** | **-0.057**** | **0.021** | **0.032**** | **0.035**** | **.** | **0.002** |
| | (0.026) | (0.025) | (0.023) | (0.016) | (0.016) | . | (0.019) |
| | | | **Negative labour spikes** | | | | |
| **> 0 spikes** | **0.014** | **-0.012** | **-0.005** | **-0.001** | **-0.034***** | **0.117** | **-0.001** |
| | (0.016) | (0.021) | (0.018) | (0.016) | (0.012) | (0.106) | (0.013) |
| **Current** | **-0.017** | **0.026** | **-0.011** | **-0.006** | **0.001** | **-0.251**** | **-0.002** |
| | (0.026) | (0.022) | (0.020) | (0.017) | (0.020) | (0.102) | (0.010) |
| **Previous** | **-0.016** | **0.024** | **-0.004** | **-0.028*** | **0.027** | **-0.070** | **0.009** |
| | (0.019) | (0.024) | (0.023) | (0.015) | (0.042) | (0.112) | (0.017) |
| **2 years** | **-0.012** | **0.007** | **-0.028** | **-0.005** | **0.068**** | **-0.259*** | **-0.005** |
| **previous** | (0.036) | (0.027) | (0.022) | (0.022) | (0.027) | (0.141) | (0.018) |
| **> 2 year** | **0.044** | **-0.008** | **0.012** | **-0.008** | **0.024** | **-0.298** | **-0.019** |
| **previous** | (0.030) | (0.018) | (0.018) | (0.012) | (0.018) | (0.191) | (0.013) |
| **Next** | **-0.032** | **0.055** | **-0.014** | **0.023** | **0.014** | **-0.118** | **-0.010** |
| | (0.024) | (0.042) | (0.022) | (0.023) | (0.014) | (0.106) | (0.016) |
| N | 587 | 185 | 344 | 551 | 60 | 515 | 575 |

| Sector | 29 | 31 | 32 | 33 | 34 | 36 | 37 |
|---|---|---|---|---|---|---|---|
| | | | | **Investments** | | | |
| > 0 spikes | 0.005 | -0.062*** | -0.020 | 0.039 | 0.040*** | 0.006 | . |
| | (0.014) | (0.004) | (0.023) | (0.035) | (0.008) | (0.006) | . |
| Current | -0.006 | -0.062 | 0.004 | -0.030 | -0.038*** | -0.062*** | 0.244 |
| | (0.025) | (0.053) | (0.016) | (0.029) | (0.014) | (0.023) | . |
| Previous | 0.004 | . | 0.202 | -0.067*** | -0.065*** | 0.004 | 0.196 |
| | (0.035) | . | (0.166) | (0.026) | (0.016) | (0.013) | . |
| 2 years | -0.010 | . | . | -0.056** | -0.093*** | -0.019 | . |
| previous | (0.019) | . | . | (0.025) | (0.019) | (0.012) | . |
| > 2 year | 0.014 | -0.150*** | -0.009 | -0.000 | -0.074*** | -0.096** | 0.625 |
| previous | (0.025) | (0.020) | (0.026) | (0.031) | (0.008) | (0.047) | . |
| Next | 0.011 | . | . | -0.051* | . | -0.022 | . |
| | (0.025) | . | . | (0.029) | . | (0.016) | . |
| | | | | **Positive labour spikes** | | | |
| > 0 spikes | 0.006 | 0.222*** | 0.145*** | 0.020 | -0.036*** | -0.025*** | . |
| | (0.009) | (0.047) | (0.033) | (0.025) | (0.011) | (0.007) | . |
| Current | -0.011 | -0.161** | -0.131*** | 0.005 | 0.009 | 0.033 | . |
| | (0.016) | (0.067) | (0.044) | (0.015) | (0.013) | (0.022) | . |
| Previous | -0.037*** | -0.151*** | -0.178*** | -0.003 | 0.001 | 0.024 | . |
| | (0.010) | (0.054) | (0.053) | (0.009) | (0.023) | (0.017) | . |
| 2 years | 0.021 | -0.063 | 0.105* | -0.017 | 0.056** | 0.024 | . |
| previous | (0.023) | (0.063) | (0.062) | (0.015) | (0.027) | (0.024) | . |
| > 2 year | -0.001 | . | -0.180*** | -0.016 | 0.009 | -0.055** | . |
| previous | (0.022) | . | (0.011) | (0.011) | (0.026) | (0.028) | . |
| Next | 0.026 | . | 0.018 | -0.011 | -0.031* | 0.059*** | . |
| | (0.024) | . | (0.019) | (0.025) | (0.018) | (0.019) | . |
| | | | | **Negative labour spikes** | | | |
| > 0 spikes | 0.034* | -0.182*** | 0.043* | 0.022* | 0.001 | 0.013 | . |
| | (0.019) | (0.038) | (0.025) | (0.013) | (0.013) | (0.008) | . |
| Current | -0.006 | 0.158*** | -0.110 | 0.027 | -0.023 | -0.033*** | . |
| | (0.032) | (0.051) | (0.146) | (0.018) | (0.048) | (0.011) | . |
| Previous | -0.029 | -0.012 | . | . | . | -0.011 | . |
| | (0.024) | (0.059) | . | . | . | (0.026) | . |
| 2 years | 0.042 | -0.133** | . | . | . | 0.004 | . |
| previous | (0.034) | (0.059) | . | . | . | (0.012) | . |
| > 2 year | -0.037* | 0.056 | 0.037** | -0.000 | -0.053** | -0.031* | . |
| previous | (0.022) | (0.040) | (0.016) | (0.015) | (0.024) | (0.017) | . |
| Next | -0.020 | 0.128*** | . | . | . | 0.046* | . |
| | (0.019) | (0.043) | . | . | . | (0.025) | . |
| N | 83 | 74 | 133 | 108 | 326 | 18 | |