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The relationship between input-factor and output prices in commodity industries: The case of Norwegian salmon aquaculture

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ABSTRACT

Using the Norwegian salmon aquaculture as a case study, this paper examines the relationship between input-factor prices and cost driven output prices. We hypothesize that as variations in marginal productivity in an industry falls, the relative importance of input-factor price variations on unit production costs increases. For maturing commodity industries, price trends will go from productivity driven to input-factor price driven. Our empirical results indicate that the correlation between salmon price and feed input-factor prices (fishmeal, soybean meal and wheat) has increased in recent years. Consistent with a period of increased importance of feed costs to developments in salmon production costs, we find evidence of an emergent protein cointegration relationship between salmon, fishmeal and soybean prices. The paper provides an empirical framework to analyze changing relationship between output and input prices, and highlights some limits to inference using price analysis.

1. Introduction

This paper examines the relationship between input-factor prices and output prices in a maturing commodity industry. Motivated by developments observed in the Norwegian salmon aquaculture industry, we hypothesize that as an industry matures, variations in marginal productivity tends to settle down due to diminished returns from R&D and learning. As a result, variation in input-factor prices becomes relatively more important to explain variation in unit production costs. This implies a stronger pass-through effect from input-factor prices to output prices. In other words, price trends move from being productivity driven to input-factor price driven. In this paper, we investigate this hypothesis empirically using annual and monthly data on Norwegian aquaculture salmon price, production costs and a set of feed raw material prices (fishmeal, soybean meal and wheat).

Using price data to infer the cause of changes in correlations and other measures of relationships between prices has some limitations. Often a multitude of changes in markets occurs over time; changes that price analysis alone cannot separately identify. For analysis of price pass-through effects from input to output prices, we highlight two market changes that are difficult to separate from causes related to production technology.

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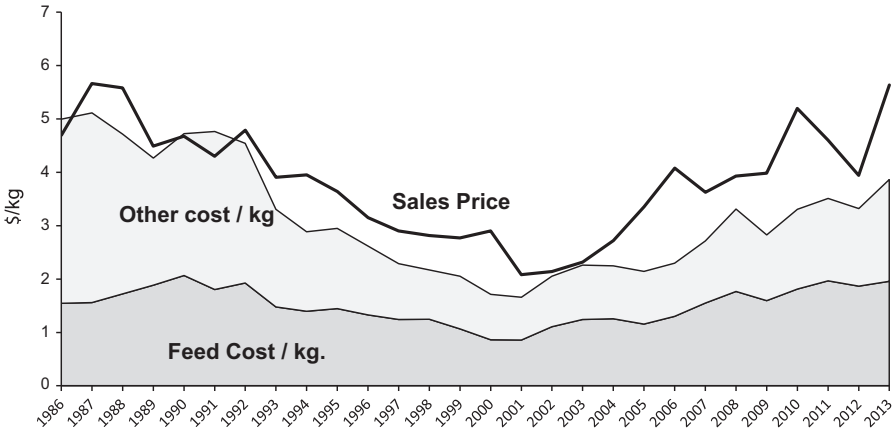

Fig. 1. Unit production costs and sales price (nominal USD values).

First, more globally integrated markets for inputs (such as different raw materials), leads to more stable relative prices. As relative prices become more stable, the ability to substitute between different inputs to mitigate production cost effects from adverse input price changes is reduced. The result is an increased observed pass-through effect from input-factor price changes to production costs. In recent years, different commodity prices have displayed large swings around relatively high price levels. This is not isolated to specific commodity groups, but is found in everything from meats and crops to energy and metals [10,24,25]. New relationships have emerged between different commodity markets. Biofuel has created new links between agriculture and energy [12,28,30,31]. This has manifested in a stronger relationship between corn, soybean and energy prices ([14,41]). Stronger cross-correlation between various inputs translates to stronger correlation also towards downstream output prices. This effect is difficult to isolate from increased pass-through due to lower variations in marginal productivity using price data alone.

Secondly, the observed relationship between input and output prices can depend on common supply/demand factors. For instance, if some food production industry uses another food product as input, increased aggregate demand for food will tend to push up both prices. The result is correlated prices due to causes outside supply chain specific supply/demand shocks. Furthermore, how a common factor influence price correlations will depend on the degree of pass-through from input-factor prices to production costs. With a strong pass-through, increased aggregate demand will increase the price of the output directly through increased demand, and indirectly through the cost of production (due to higher input-factor prices because of higher demand). Margins in the output industry will remain relatively constant, and there will be less incentive to increase production. System formulations of price adjustments, such as VECM models, can provide information on the degree of price leadership in markets. Since increased pass-through effect implies stronger price leadership from input-factor markets, we can infer to what degree a stronger relationship is due to stronger pass-through or to stronger dependence on common factors. However, making valid inference on price leadership requires that price discovery is based on similarly timed information sets on supply/demand factors. This paper will use different approaches to analyze the relationship between input-factor and output prices, with a focus on pass-through effects and common factor dependence.

The empirical analysis is based on monthly observations of commodity prices from the World Bank pink sheet, and on annual data on salmon sales price and production costs from the Norwegian Directorate of Fisheries. Analysis of the annual data (denoted in nominal dollar value) suggests that the salmon price trend is to a large degree cost driven, and that feed raw material prices determine unit production costs and the sales price. The relationship is strongest statistically when the data is measured in US dollar (USD) which most feed inputs are denoted in, but is present for the data both Norwegian kroners (NOK) and Euro, which is the currency for most consumption. Rolling window correlation and principal component analysis of monthly salmon, fishmeal, soybean and wheat prices show evidence of increased correlation in recent years (from around the 2000s). We also find strongest evidence of cointegration in this period. This long-run relationship appears to be mostly a protein relationship (wheat plays a minor role). This finding supports the hypothesis that as the salmon industry has matured, the salmon price trend has become more input-factor price driven. Looking in detail on the stochastic trends in the prices, the raw material price trends appear more strongly reflected in the salmon price. However, we are unable to ascribe this fully to increased price pass-through. Analysis of price adjustments and variance decomposition suggests some of the emergent protein relationship is due to stronger dependence on some market common factor(s), such as aggregate protein demand.

This paper is organized as follows. In the next chapter, we provide some background information on our case study, the Norwegian salmon aquaculture industry. Due to the importance of feed as an input-factor, we have a section on the salmon feed. In chapter 3, we analyze publically available annual data. We describe a simple model that relates the salmon price to unit production costs and feed raw material prices, and proceed to estimate empirical versions of the model. We highlight the limits to inference with this data, as well as the role of currency choice for the analysis. In chapter 4, we move to