Productivity, Demand and Innovation

Purpose of project:

The overall objective of this project is to improve our understanding of productivity effects of different types of innovation. Especially, we want to estimate the separate productivity effects of product and process innovation on firm productivity.

Innovation will impact the demand – through product innovation – and productivity – through process innovation. The innovation elasticity will therefore be a combination of output elasticity and price elasticity (see Hall et al., 2010, and Hall, 2011). Prior research did not identify these two effects separately because of lack of data on individual firm prices. However, using the data from Statistics Denmark on international trade and domestic sales, we will be able to measure the separate influences of innovation on prices – measured by unit values – and output. According to our knowledge it is the first time that an empirical study of innovation and unit values of firm sales has been carried out.

The question of the productivity effects of different types of innovation is not only of theoretical interest but will also have profound implications for public policy. This holds for measures directed towards individual firms' innovation (to what extent do process and product innovation enhance firms productivity or revenue?) and for policy measures directed towards innovative firms (what type of innovations should governments subsidize?)

We apply for funding of DKK 358,857 to carry out this research project. The project is expected to be finalized mid-2012. The aim of the project is to publish a paper in A-level journals; either in an economics or a business economics journal.

Research question and policy issues:

What is the relationship between innovation, productivity and demand? Firms have different strategies with respect to innovation. Some firms perform product innovations, others perform cost-saving innovations, and some firms have both types of innovations. In the Danish survey data for 2007, 40 percent of innovation active firms perform product innovation only, 20 percent perform process innovation only, whereas 40 percent perform both types of innovations. In this respect it is of great interest to understand if some innovation strategies lead to higher levels of productivity and/or demand than other strategies.

Having measures of unit values of products – both sold in the international and domestic markets – enables us to study within product-price effects of different innovation types. This approach combines the cost-reducing and product-creating aspects of innovation, as well as allowing for imperfect competition, scale economies and markup pricing. One interesting aspect in this case is to understand if some innovations have different effects on prices charged domestically and abroad.

This type of project is expected to have interest in the policy community for example from the Ministry of Economics and Business Affairs.

Background

In the recent empirical evidence on innovation and productivity at the firm level, the focus is on product and/or process innovation. It is found that there are substantial positive impacts of product innovation on productivity, but that the impact of process innovation is more ambiguous and unexpectedly found to be negative in some cases, see Hall (2011).

One important drawback of empirical studies is that the applied measure of productivity is based on *real revenues* or *real value added*; not *real quantities* produced at the firm level. The latter is the theoretical

correct measure that productivity should be based on. The use of revenue productivity can actually lead to the counter-intuitive negative impact of process innovation on firm productivity. It is useful to illustrate this result. To do this we present a simple model that follows an example presented in Hall et al (2010) and Hall (2011). The production function in log form is given by:

$$q_{it}=a_{it}+\alpha c_{it}+\beta l_{it}+\gamma k_{it}^c$$

where c_{it} is the real capital stock, l_{it} is labor input and k_{it}^c is knowledge capital generate through process innovation. Moreover, γ is the positive elasticity of process innovation.

The firm faces a downward sloping iso-elastic demand curve that is given by

$$q_{it}= \eta p_{it}+\varphi k_{it}^p$$

in log form. Here, p_{it} is the firm specific price (deflated by an overall deflator) and k_{it}^p is knowledge capital obtained through product innovation. Moreover, η is the negative price elasticity, whereas φ is a positive elasticity of product innovation.

The two equations can be combined to express real revenue, resulting in the equation that is used for estimation purposes in empirical studies:

$$p_{it}+q_{it} = (\eta+1/\eta)(a_{it}+\alpha c_{it}+\beta l_{it})+\gamma(\eta+1)/\eta k_{it}^c-\varphi/\eta k_{it}^p$$

The equation shows that innovation will contribute to revenue through two channels: directly by increasing the efficiency of production through process innovation and indirectly by shifting the demand curve for the firm's products outward through product innovation. The effect of product innovation will always lead to higher real revenues since $-\varphi/\eta > 0$. On the other hand, the effect of process innovation on revenue productivity is determined by a combination of the output elasticity of process innovation, i.e., γ, and the price elasticity, i.e., η. If the typical firm operates on the inelastic part of the demand curve implying that $0>\eta>-1$, the term $\gamma(\eta+1)/\eta$ is negative, implying that firm revenues fall when knowledge capital generated through process innovation increases; a result that is found in empirical studies. This can be interpreted the following way: the typical firm enjoys some market power and operates in the inelastic portion of its demand curve so that revenue productivity falls when it becomes more efficient.

The magnitude and sign of the elasticity of demand (η) for different markets are empirical issues. The simple model outlined above could lead to inconsistencies in the firms' pricing rules depending on the size of η. However, in the empirical implementation, we plan to control for the competitive environment facing our sample firms to avoid having situations in which, e.g. the optimal pricing rule would be to let the price go to infinity.

For full identification data on individual firm *output prices* are required to allow separate estimation of η and φ. Estimates for these parameters in the demand function, will allow for point estimates of γ. As a consequence, the direct effect of increasing the efficiency of production through process can be determined.

Methodology and Data:

It should be emphasized that the survey and register data from Statistics Denmark make the empirical studies feasible. The Danish data is unique – and according to our knowledge – no other data sources in the world are available to make similar empirical studies.

The two main data sources that we will use are:
- "Innovation Surveys" (CIS-surveys) and "R&D surveys" collected by Statistics Denmark.
- Firm-level information on external trade and domestic sales broken-down by product types. The former data source covers all Danish firms that export goods and products; the latter statistics cover

all Danish manufacturing firms with more than 10 employees. Using these sources it is possible to construct measures of "unit values" for domestic sales and exports. It is these measures that will be interpreted as firm-level prices. These variables are possibly subject to measurement errors, but certainly convey useful information. For example, Nguyen (2009) uses this information to analyze whether quality differences or cost differences drive firm-level export revenues. Moreover, Hummels et al. (2011) use these unit values to study the relationship between a firm's choice of factor inputs and its ability to charge higher prices in export markets.

The project will also draw on the matched worker-firm data in FIDA of Statistics Denmark. A large part of the project will use econometric methods. The relationship between innovation, productivity and demand will be analyzed in a semi-structural way (see e.g., Foster et al., 2008).

The question of the productivity effects of different types of innovation is not only of theoretical interest but will also have profound implications for public policy. This holds for measures directed towards individual firms' innovation (to what extent do process and product innovation enhance firms productivity or revenue?) and for policy measures directed towards innovative firms (what type of innovations should governments subsidize?)

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Application for funding from Economic Policy Research Network

Participants

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Budget

Wage for Cedric Schneider – 2 måneder i 2011/2012	DKK 78,784
Wage for Anders Sørensen – 2 måneder i 2011/2012	DKK 130,263
Wage for a research assistant	DKK 70,000
Travel costs related to project (participation in conferences etc.)	DKK 20,000
Total amount, excl. overhead:	DKK 299,047
Overhead (20% of total amount)	DKK 59,809
Total amount, incl. overhead:	DKK 358,857