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# Innovation, Firm Risk and Industry Productivity

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## Innovation, Firm Risk and Industry Productivity


**Abstract**

Radical innovations require risk-taking. However, it is hard to find an objective measure for innovation investments that would take riskiness into account. In this paper, we investigate how a simple measure of firms' innovation investments, namely the employee share of managers and professionals, is associated with profit risk at the firm level. Using data that cover essentially all firms in the Finnish business sector, we first document that labor productivity dispersion is very high among firms with a high employment share of managers and professionals. We also find that the dispersion in the return to firms' total capital is particularly high among young firms with a high employment share of managers and professionals. We then build a simple model where firms' innovation activities and firm risk are interrelated. We use the model to analyze how the asymmetric tax treatment of profits and losses in corporate taxation influences firms' innovation decision in market equilibrium and whether innovation subsidies can improve industry productivity by mitigating such a tax distortion.



**Key words:** Productivity, R&D, innovation, corporate taxation

**JEL:** E23; L16; O47


## Innovaatio, yritysriski, ja toimialan tuottavuus


**Tiivistelmä**

Tässä tutkimuksessa tarkastellaan yritysten innovaatiointensiivisyyden ja yrityksiin sijoitetun pääoman tuottoon liittyvän riskin välistä yhteyttä. Innovaatiointensiivisyyttä mitataan johtajien ja erikoisasiantuntijoiden työvoimaosuudella. Kattavaan yritysaineistoon perustuva empiirinen analyysi osoittaa, että varsinkin nuorten yritysten osalta kokonaispääoman tuotto vaihtelee selvästi eniten erittäin innovaatiointensiivisten yritysten keskuudessa. Kokonaispääoman tuoton vaihtelu on näissä yrityksissä keskihajonnalla mitattuna lähes kaksinkertainen samanikäisiin matalan innovatiivisuuden yrityksiin verrattuna. Lisäksi nuorten innovaatiointensiivisten yritysten keskimääräinen tuotto oli suhteellisen matala. Innovaatiointensiivisten yritysten kokonaispääoman tuotto nousee muiden yritysten tasolle vasta usean vuoden jälkeen yritystoiminnan aloittamisesta. Tutkimuksessa kehitetään myös yritysten innovaatiopanostusten ja riskinoton yhteyttä kuvaava teoreettinen malli, jonka avulla voidaan tarkastella riskinoton kannustimien merkitystä yritysten innovaatiovalintojen ja toimialan tuottavuuden kannalta. Mallitulosten mukaan esimerkiksi nykyiseen yritysverotukseen liittyvästä voittojen ja tappioiden epäsymmetrisestä verokohtelusta seuraa, että yritykset investoivat toimialan tuottavuuden kannalta liian vähän korkean riskin innovaatiotoimintaan.



**Asiasanat:** Tuottavuus, T&K, innovaatiot, yritysverotus

**JEL:** E23; L16; O47

# 1 Introduction

Investments into intangible capital with the aim of achieving radical innovations are arguably very risky. The measurement of such investments with large firm data poses a great challenge, however. In this paper, we first investigate whether a simple measure that corresponds to a very broad definition of innovation, namely the employee share of managers and professionals, helps to predict investor risk at the firm level. This measure essentially captures the bulk of spending on intangible capital needed for innovative efforts (see Corrado, Hulten ja Sichel, 2009).[1] Maliranta (2014) found that productivity dispersion as well as productivity-enhancing resource reallocation are very high among firms that are relatively innovation intensive, based on this measure. We are interested in seeing, first of all, how those results relate to profit risk. We measure profit risk with the dispersion in the return to firms' total assets.

Using data that cover essentially all firms in the Finnish business sector, we find that among young firms, those with high employee share of managers and professionals are indeed more risky in terms of their return to total assets than other firms. Interestingly, however, such a link between innovation intensity and firm risk does not seem to be present among older firms, even though innovation employment is still strongly correlated with productivity dispersion. We also investigate whether firms with a high innovation employment share tend to have a high equity share as well. Our assumption is that because of financial market imperfections, firms that are risky in terms of profitability are likely to need more equity in order to finance their investments than less risky firms. We find some evidence that young firms with a relatively low innovation employment share have a lower equity share than other firms. However, this pattern is not very robust.

Having established these results, we consider some policy implications. The fact that the employee share of managers and professionals is correlated with firm level risk at least among young firms suggests that it may be a useful proxy for risky innovation investments. Arguably, it can therefore be used as a basis for innovation subsidies or tax allowance for innovation, at least together with information about e.g. employees' educational background so that firms cannot simply label production workers as professionals. Indeed, tax allowances for innovation subsidies are often conditional on similar relatively simple measures of the share of personnel that can be classified as doing innovation.

Another issue is that the observation that innovation intensity and firm risk are correlated (among young firms) may provide a rationale for subsidizing innovation activities. This is because, as is well known, a typical corporate tax system tends to discourage risk-taking by firms (see e.g. Mirrlees et al., 2011, chapter 18).[2] One reason is the asymmetric tax treatment of profits and losses: Positive profits are taxed but negative profits usually do not attract a full tax rebate. Corporate tax systems also tend to favor debt financing over equity financing. Unlike interest payments on debt, the cost of equity is not deductible. Hence, equity is subject to double taxation: First at the corporate level and then at the personal level. To the extent that risky investments force firms to rely largely on equity financing, this provides yet another distortion against risk taking. Unless we are willing to reform the corporate tax system so as to elim-

[1] In our view the inclusion of both managers and professionals is justified because innovations typically involve technical, organizational and commercial aspects.

[2] See e.g. Cullen and Gordon (2007) for empirical evidence showing that taxation generally matters a great deal for business creation.

inate these distortions, we may want to consider subsidizing innovation investments in order to mitigate the tax distortions.

On the other hand, subsidies tend to create new distortions. In order to study this kind of policy questions, we build a model where firms' decisions related to innovation investment and risk-taking are interrelated. In the model, potential entrants decide whether to choose to operate in a risky mode, which requires large innovation investments, or in a safer mode where the firm can rely largely on existing and tested technologies. We use the model to illustrate, first of all, how a tax distortion that discourages risky innovation influences firms' decisions in the market equilibrium. We also use the model to analyze whether such a tax distortion in itself justifies the introduction of innovation subsidies.

We find that the tax distortion (asymmetric tax treatment of profits and losses) decreases the share of firms choosing the risky innovation mode. At the same time, it decreases industry productivity and productivity dispersion between firms.[3] We also find that given the tax distortion, an appropriate innovation subsidy can indeed improve productivity. In the model, the government can eliminate most of the fall in industry productivity that is caused by the asymmetric tax treatment of profits and losses with an optimal innovation subsidy. This result is solely based on the fact that the tax system distorts firms' decisions regarding risk taking: In the absence of the asymmetric profit tax, the optimal subsidy rate would be zero because we abstract from other reasons to provide innovation subsidies such knowledge spillovers.

In the next section we describe the data and discuss some measurement issues. In section 3 we present the empirical results. In section 4 we describe the theoretical model and use it to analyze certain policy measures. We conclude in section 5.

## 2 Data

We use Statistics Finland's comprehensive financial statement data panel from the years 2004-2009 which is matched with the register-based employment statistics database with the firm identifier. These data are called the Finnish Longitudinal Employer-Employee data (FLEED)[4]. The financial statement data contain yearly financial statement information of 95–99% of the Finnish enterprises. Labour productivity is measured as value added per persons engaged in the full-time equivalent units, which gives us a simple indicator of efficiency. The employment-weighted standard deviation of labour productivity indicates the heterogeneity of the jobs in terms of efficiency. Profitability is measured with the return on assets (ROA) defined as net profits + interest expenses + profit taxes divided by firm's total assets in its balance sheet. We measure firm risk with the weighted standard deviation of ROA with weights corresponding to firms' total assets. The financial statement data also allows us to consider the equity share, which is defined as the share of firm's own capital relative to total assets in its balance sheet. We include only industrial firms employing not less than two persons (measured in full-time equivalent units) and exclude observations with a non-positive or missing overall balance.

[3] Note that here a low productivity level is associated with a low productivity dispersion although according to the literature examining technical inefficiency of firms a low productivity dispersion should be an indication of low inefficiency and thus high productivity level (see Caves, 1992).

[4] As for more information on data, see http://www.stat.fi/tup/mikroaineistot/me_kuvaus_henkilo_en.pdf

By the use of occupational information from the FLEED data we have computed the employment share of the innovators comprising of the managers[5] and professionals[6] for each firm in the data. In what follows, we sometimes refer to this as "innovation employment share". As discussed in the Introduction, this share provides us with a measure for firm's innovation activity in the spirit of Corrado ym. (2009). We first classify firms into three groups according to whether their average innovator share in all available years is less than 10%, between 10–20%, or more than 20%. We also consider separately young and old firms. We classify firms as "young" if they are less than 5 years old. Of course, these classifications are somewhat arbitrary. However, as we show below, the main results are not very sensitive to changes in these limits

After merging data sets and using our inclusion criteria we have a data containing 56 439 observations from 13 236 enterprises for years 2004–2009. The number of observations is 27 839 when the average innovator share is less than 10%, 27 700 when the share is between 10% and 20% and 15 900 when the share is at least 20%.

We are interested in the strategic differences between firms operating in the same markets in terms of innovation activity. Therefore throughout the paper we focus on the differences within industries (defined at the 2-digit industry level) and refer to the employment-weighted averages of the industry-level results. In other words, we take into account the fact that the industry-structures of the firms may vary by their innovation intensity (i.e. innovation intensive firms are overrepresented in certain industries).

## 3 Empirical results

In addition to considering firms with different innovator share, we also consider firms of different age. This is to see whether there are systematic differences in the firm life cycles between firms with different innovation employment share. We first compare firms that are less than 5 years old with older firms. Table 1 presents results about labour productivity, return on total capital (ROA), and equity share.

The first rows of the Table relate to labour productivity. Both the average labour productivity and especially productivity dispersion increases with the innovation employment share. The standard deviation of labour productivity is over three times as high in the group where innovation employment share is over 20% than in the group where it is less than 10%. This result also holds for young and old firms separately: labor productivity and productivity dispersion increase with innovation both among young and older firms.

An interesting finding concerns the group of the most innovative firms: young firms have higher productivity dispersion and a lower productivity level than older firms. Among less innovative firms the difference between young and older firms seems to be insignificant both for the average productivity level and dispersion. These findings seem to fit with the idea that heterogeneity in the outcomes of innovation pertain to young firms in particular.

[5] Group "1" in the ISCO88 occupation classification.

[6] Group "2" in the ISCO88 occupation classification.

The following rows in Table 1 display the results related to ROA. Let us first consider firms where the innovation employment share is less than 10% with those where the share is above 20%. For firms of all ages, the mean ROA is roughly the same in both groups (8.4% vs. 8.1%) while the standard deviation of ROA is somewhat higher among firms with a high innovation employment share (16.1% vs. 13.7%). Interestingly, these differences are much larger among young firms. The mean return is 9.9% among young firms with a low innovation employment share and just 4.2% among young firms with a high innovation employment share. The standard deviation of ROA is 15.9% in the former group and 24.4% in the latter group. In other words, young firms with a high innovation employment share appear to provide a relatively low and very risky return to investors. It should be noted, however, that the link between innovation employment share and profit risk (or dispersion in the return to total assets) is not monotone in the Table. In fact, the risk appears to be the lowest in the middle group. It may be that only very intensive innovation activities are associated with additional risk related to innovation.

The last of row in Table 1 displays the mean share of own capital. In most groups the share of own capital is slightly above 40%. Interestingly, the share is much lower among young firms with a low innovation employment share (30.6%). As we discussed in the Introduction, one possible interpretation of this result is that due to financial market imperfections, firms that invest in risky innovation projects need to rely largely on equity finance. However, the relation between the equity share and the innovation employment share does not follow a clear pattern. The equity share is roughly the same in all other firms groups except young firms with a low innovation employment share.

Tables 2 and 3 present the same moments than Table 1 but using slightly different age limits. Table 4 in terms uses a different grouping for in the innovation employment share. The results do not change much. In particular, the standard deviation of ROA is clearly the highest in the group of young firms with a high innovation employment share independently of the precise age limit or innovation employment share grouping used. In Table 4, however, the profit risk now increases monotonically with the innovation employment share.

As we discussed in the Introduction, tax systems tend to discourage risk taking at the firm level. Since innovation intensive firms appear to be riskier than other firms, this may imply that

**Table 1 Labor productivity, return on total capital, and equity share in different firm groups**

| | *Innovation employment share* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *<10%* | | | *10–20%* | | | *>20%* | | |
| | *Age<5* | *Age≥5* | *All* | *Age<5* | *Age≥5* | *All* | *Age<5* | *Age≥5* | *All* |
| **Labor productivity, 1000 euros** | | | | | | | | | |
| mean | 55.2 | 55.3 | 55.0 | 69.7 | 70.8 | 72.4 | 70.3 | 79.3 | 78.4 |
| standard deviation | 28.7 | 28.1 | 28.5 | 38.5 | 41.8 | 44.0 | 93.8 | 84.3 | 91.2 |
| **Return on total capital, %** | | | | | | | | | |
| mean | 9.9 | 7.9 | 8.4 | 7.1 | 4.5 | 4.6 | 4.2 | 8.6 | 8.1 |
| standard deviation | 15.9 | 12.9 | 13.7 | 9.9 | 11.7 | 11.5 | 24.4 | 11.3 | 16.1 |
| **Share of own capital, %** | | | | | | | | | |
| mean | 30.6 | 41.2 | 40.1 | 37.2 | 41.5 | 41.6 | 43.8 | 43.4 | 43.7 |

**Table 2 Labor productivity, return on total capital, and equity share; age limit 4 years**

| | *Innovation employment share* | | | | | |
|---|---|---|---|---|---|---|
| | *<10%* | | *10–20%* | | *>20%* | |
| | *Age<4* | *Age≥4* | *Age<4* | *Age≥4* | *Age<4* | *Age≥4* |
| **Labor productivity, 1000 euros** | | | | | | |
| mean | 54.0 | 55.2 | 69.1 | 71.2 | 68.7 | 79.8 |
| standard deviation | 22.8 | 29.4 | 36.9 | 41.9 | 98.4 | 83.1 |
| **Return on total capital, %** | | | | | | |
| mean | 9.3 | 8.0 | 7.1 | 4.3 | 4.0 | 8.7 |
| standard deviation | 14.9 | 13.3 | 10.1 | 11.6 | 26.6 | 12.0 |
| **Share of own capital, %** | | | | | | |
| mean | 31.2 | 40.7 | 36.1 | 41.6 | 43.4 | 43.6 |

**Table 3 Labor productivity, return on total capital, and equity share; age limit 6 years**

| | *Innovation employment share* | | | | | |
|---|---|---|---|---|---|---|
| | *<10%* | | *10–20%* | | *>20%* | |
| | *Age<6* | *Age≥6* | *Age<6* | *Age≥6* | *Age<6* | *Age≥6* |
| **Labor productivity, 1000 euros** | | | | | | |
| mean | 54.6 | 55.5 | 70.4 | 70.1 | 68.7 | 79.3 |
| standard deviation | 29.1 | 28.2 | 38.8 | 41.3 | 91.4 | 85.1 |
| **Return on total capital, %** | | | | | | |
| mean | 9.4 | 8.0 | 7.1 | 4.6 | 3.7 | 8.8 |
| standard deviation | 16.4 | 12.7 | 9.7 | 11.9 | 22.4 | 11.2 |
| **Share of own capital, %** | | | | | | |
| mean | 31.0 | 41.5 | 37.6 | 42.0 | 43.4 | 43.4 |

taxation discourages innovation investments. One reason why taxation discourages risk taking is the asymmetric tax treatment of profits and losses. Losses do not give rise to a tax rebate equivalent to the tax on positive profits. As a result, the expected profit is typically decreasing in profit uncertainty. Loss-offsetting rules mitigate this problem but cannot remove it completely. As an extreme example, we can consider a firm that never makes profits. Such a firm can never use its losses to offset profits during its life cycle.

Our data allows us to illustrate this issue. We can compute how much a given profit tax lowers the expected return to total capital in different firm groups. For instance, a profit tax of 20% would lower the average return to total capital among young firms with innovation employment less than 10 % in table 1 by 23% relative to the before-tax return reported in the table. This is calculated by applying the profit tax to positive profits only. In the case of young firms with an innovation employment share above 20%, the average return falls by 28%.

**Table 4 Labor productivity, return on total capital, and equity share; innovation employment limits 15% and 25%**

| | *Innovation employment share* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *<15%* | | | *15–25%* | | | *>25%* | | |
| | *Age<5* | *Age≥5* | *All* | *Age<5* | *Age≥5* | *All* | *Age<5* | *Age≥5* | *All* |
| **Labor productivity, 1000 euros** | | | | | | | | | |
| mean | 56.8 | 61.7 | 61.0 | 71.4 | 69.0 | 70.9 | 63.6 | 76.8 | 75.4 |
| standard deviation | 27.9 | 32.8 | 32.7 | 38.7 | 47.1 | 47.5 | 109.9 | 96.0 | 105.1 |
| **Return on total capital, %** | | | | | | | | | |
| mean | 7.2 | 6.2 | 6.3 | 9.0 | 7.2 | 7.5 | 3.7 | 8.1 | 7.6 |
| standard deviation | 13.3 | 11.8 | 11.9 | 16.2 | 14.6 | 14.9 | 25.7 | 11.1 | 16.7 |
| **Share of own capital, %** | | | | | | | | | |
| mean | 36.8 | 40.8 | 41.8 | 27.8 | 47.5 | 44.6 | 43.6 | 42.7 | 43.2 |

# 4 The model

In this section, we develop a stylized model of firms' innovation decisions that captures some key patterns revealed by the empirical results and use it to analyze related policy issues. In particular, we consider how the asymmetric tax treatment of profits and losses influences firms' innovation decisions in the market equilibrium and discuss the potential role of innovation subsidies. In this respect, an important aspect of the model is that firms' decisions regarding risk taking and innovation are not always one-to-one-related. Poorly designed innovation subsidies may induce firms to invest in less risky innovation projects.

## 4.1 Set-up

Firms can operate in one of two modes. In mode 1, they largely rely on a technology that has been developed elsewhere and invest relatively little in innovation. In mode 2, firms rely largely on their own technology and thus need to invest heavily in innovation.

In order to enter the market, a firm has to pay a fixed entry cost $\kappa$. Once a firm has paid the entry cost, it observes a stochastic variable $z$ that determines its ability to operate in modes 1 and 2. For simplicity, we assume that the firm's ability to operate in mode 1 and its ability to operate in mode 2 are perfectly negatively correlated. As a result, we can take $z$ to be scalar. Upon observing $z$, the firm decides whether to enter the market in mode 1 or mode 2, or whether to exit the market immediately. If the firm chooses to enter the market it also decides upon its innovation employment denoted by $r$. The optimal innovation employment depends on the mode.

The firm's profit depends on the knowledge capital that is generated by its innovation investment. Given innovation investment $r$ and $z$, knowledge capital in mode 1 is determined as $a = e^{-z+\varepsilon^1} r$, where $\varepsilon^1 \sim N(0, \sigma_{\varepsilon^1})$ is a stochastic term. The knowledge capital in mode 2 is determined as $a = e^{z+\varepsilon^2} r$, where $\varepsilon^2 \sim N(0, \sigma_{\varepsilon^2})$ is stochastic term. Notice that given innovation employment $r$, the expected amount of knowledge capital in mode 1 is lower the higher is $z$, while the expected knowledge capital in mode 2 increases with $z$. We assume $\sigma_{\varepsilon^2} > \sigma_{\varepsilon^1}$, reflecting the assumption that innovation in mode 2 is inherently riskier than in mode 1.

Given knowledge capital $a$, mode $i$, and innovation investment $r$, the firm chooses the amount of its non-innovation employment $l$. Its profit is determined as:

$$\mathrm{v}^i(\mathrm{a},\mathrm{r}) = \max_l \left\{ a^{\alpha_i} l^{\gamma_i} - wl - wr - \kappa - T(a,l,r;i) \right\} , \tag{1}$$

where $w$ is the wage rate, $\kappa$ is a fixed operating cost (which is assumed to be the same as the entry cost), and $T(a,l,r;i)$ captures taxes and subsidies. We assume $\alpha_2 > \alpha_1$, $\gamma_1 > \gamma_2$, and $\alpha_1 + \gamma_1 < 1$ for $i = 1,2$. That is, the share of knowledge capital in the production function is larger in mode 2 and the production function displays decreasing returns to scale with respect to knowledge capital and production workers.

Entrants choose the operating mode based on expected profits. The expected profits (given optimal $r$) in mode 1 and 2 are determined, respectively, as

$$\mathrm{v}^e(z,1) = \max_r \int \mathrm{v}^1(e^{-z+\varepsilon^1} r, r) d\varepsilon^1 \tag{2}$$

and

$$\mathrm{v}^e(z,2) = \max_r \int \mathrm{v}^2(e^{z+\varepsilon^2} r, r) d\varepsilon^2 \tag{3}$$

If $\mathrm{v}^e(z,\mathrm{i}) < 0$ for $i=1,2$, the firm chooses to exit immediately without employing any labour. Otherwise it chooses the mode with higher expected profits.

The free-entry condition reads as:

$$\int \max \left\{ v^e(z,1), v^e(z,2), 0 \right\} \varphi(dz) - \kappa = 0 \tag{4}$$

In other words, the expected-profit from entering the market equals the fixed entry cost. This condition pins down the wage level $w$. We close the model by assuming that the aggregate labor supply is fixed. Without loss of generality, we normalize it to 1. The mass of firms is determined so that the demand for labor equals its supply.

We consider a simple profit tax without loss offset and a subsidy to innovation employment. We have

$$T(a,l,i) = \begin{cases} s^i wr + \tau(a^{\alpha_i} l^{\gamma_i} - wl - wr - 2\kappa), \text{ if } a^{\alpha_i} l^{\gamma_i} - wl - wr - 2\kappa > 0 \\ 0, \text{ otherwise} \end{cases} \tag{5}$$

where $\tau \geq 0$ is the profit tax rate and $s^i$ denotes the innovation subsidy. We assume that the firm can deduct both the entry cost and the operating cost (which are equal). The innovation subsidy is proportional to the innovation wage bill. We will contrast two cases according to whether or not the subsidy can be made conditional on the mode. In the latter case we have $s^1 = s^2$. For simplicity, we assume that the government can balance its budget with lump-sum taxes on workers.

## 4.2 Numerical example

We analyze the model numerically. To that end, we first need to specify all parameter values. We try to choose the parameter values so as to provide an illustrative example.

We think of the two modes in the model as representing firms with a relatively small innovation share and a relative high innovation share in our empirical data. We first assume that $\alpha_1 + \gamma_1 = 0.9$ for $i = 1,2$ so that production function features less than but close to constant returns to scale in innovation and production employment. We further set $\alpha_1 = 0.1$ and $\alpha_2 = 0.3$ implying that the average innovation employment share is roughly three times as high in mode 2 as in mode 1. We assume that z is drawn from a uniform distribution between -1 and 1. Hence, entrants with a negative z have a relative advantage in operating in mode 1. We assume that innovation in mode 1 is completely risk-less by setting $\sigma_{\varepsilon^1} = 0$.

In the baseline case we set that profit tax at $\tau = 0.25$ (roughly the average corporate tax rate in Finland during the last decade or so) and abstract from subsidies. We are left with the fixed operating cost ($\kappa$) and the standard deviation of innovation shocks in mode 2 ($\sigma_{\varepsilon^2}$). We choose these parameters so that given a profit tax of 25%, the employment share of firms in mode 1 is about one half and some 10% of the firms choose to exit immediately. This results in $\sigma_{\varepsilon^2} = 1.2$ and $\kappa = 0.1$.

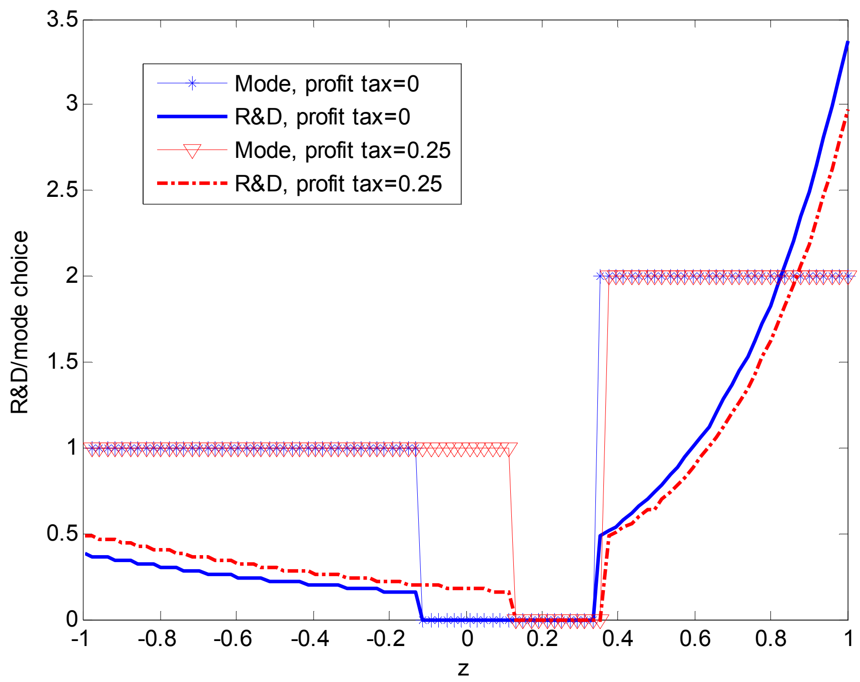
## 4.3 Policy analysis

Figure 1 illustrates the workings of the model and the effect of an asymmetric profit tax. It displays the optimal mode choice and innovation investment for different levels of the initial innovation ability shock z. In the figure, mode choice 0 indicates that the firm chooses to exit the market. Firms with a very small (negative) z choose mode 1 while firms with a large z choose mode 2. In mode 1, innovation investment decreases with z, as larger z implies that innovation investments are less productive. In mode 2, innovation investment increases with z. Firms with z close to zero choose to exit. This is because their innovation investments would be relatively unproductive in both modes.

The profit taxes influences, first of all, the allocation of firms across mode 1, mode 2, and immediate exit. Because profits in mode 2 are very uncertain, the asymmetric tax treatment lowers the expected profits especially in mode 2. As a result, the output tax induces a larger share of entrants to choose mode 1 and a lower share of entrants to choose mode 2. Interestingly, the main effect in the figure is that the share of entrants choosing mode 1 increases. The decrease in the share of entrants choosing mode 2 is much smaller in absolute terms. As a result, a smaller share of entrants chooses to exit immediately. To understand this result, it is important to take into account that the profit tax decreases the equilibrium wage rate. Given $z$, this increases the expected profit in mode 1 where the asymmetric tax treatment of profits and losses is less of an issue.

The introduction of the profit tax also distorts firms' innovation decision within each mode. Following the introduction of the profit tax, for any given z, firms choosing mode 1 invest more in innovation and firms choosing mode 2 invest less in innovation. Again, this relates to changes in the equilibrium wage level. A tax system that discourages risky innovation invest-

**Figure 1 Mode choice and innovation with and without a profit tax**




ments effectively encourages less risky innovation investments via its effect on the equilibrium wage rate.

In the model economy, industry productivity can be defined as aggregate output less fixed entry and operating costs paid by firms divided by aggregate labor (*r* and *l*). By distorting firms' choices, the profit tax also lowers aggregate productivity.[7]

Naturally, starting from a situation where the tax system distorts innovation decisions, the most straightforward way of improving productivity (and welfare) would be to eliminate such distortions. However, that is easier said than done. In the real world, a tax rebate on losses might lead to problems. For instance, multinational firms can shift their profits or losses across countries. It is therefore relevant to ask, whether we could mitigate the tax distortions with innovation subsidies.

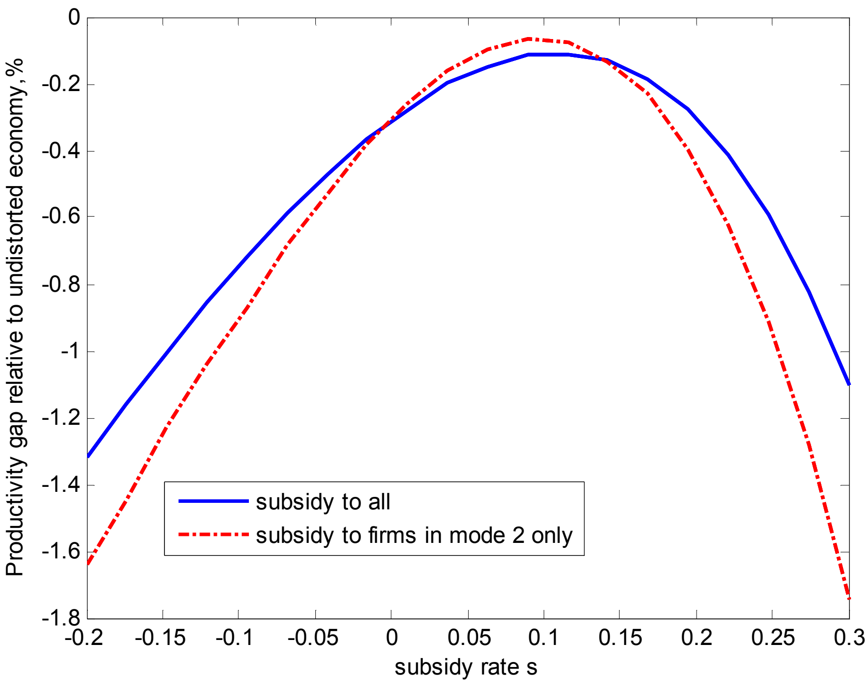
In order to illustrate how such subsidies would work, we consider two simple subsidy schemes. In the first scheme, the government provides an innovation subsidy to all firms ($s^1 = s^2$). In the second scheme, the subsidy is restricted to firms operating in the risky mode ($s^1 = 0$). Figure 2 displays industry productivity as a function of the subsidy rate *s*. In the figure, productivity is displayed relative to productivity in the case without a profit tax or subsidies. For illustration, we also consider negative subsidies (i.e. taxes on innovation activities).

[7] Quantitatively, the effect is not large in this example. The profit tax lowers aggregate productivity by about 0.5% (see Figure 2). On the other hand, as we discussed above, in reality the tax system is likely to discourage risk-taking decision in several ways. The model captures only one potential distortion, namely the asymmetric tax treatment of profits and losses. It is also possible that this type of innovation distortions influence the growth rate of productivity, and not just its level.

The figure shows that, in principle at least, the tax distortion can indeed justify innovation subsidies. In fact, in the model economy, an appropriate innovation subsidy can close most of the productivity gap created by the tax distortion. In this example, the optimal tax rate is about 10% if the subsidy is given to all firms. If the subsidy is targeted to firms choosing the risky mode, the optimal subsidy rate is slightly lower.

The figure also suggests that a subsidy that is conditional on firms choosing the risky innovation mode is more efficient in mitigating the tax distortion than an innovation subsidy that is given to all firms. However, it should also be noted that as we increase the subsidy beyond its optimal level, industry productivity falls quickly. This is because the subsidy introduces yet another distortion into the economy inducing firms to invest too much in innovation activities. Naturally, there is also no reason to tax innovation activities in this model: a negative subsidy rate implies a productivity loss as well.

**Figure 2 Innovation subsidies and industry productivity**



## 5 Discussion and conclusions

We have considered the link between firm's innovation intensity and firm risk. As a measure of innovation activity or intensity, we used the employment share of managers and professionals, which corresponds to a very broad definition of innovation. We found that among young firms, the dispersion in the return to firms' total capital is particularly high among innovation intensive firms. Also the mean return among young firms is lower for innovation intensive firms than for less innovation intensive firms.

For one thing, these observations stress the importance of well-functioning financial markets for innovation. Innovation requires investors that are willing to bear high risk and have a relatively long investment horizon. They also suggest that policies that discourage firm risk-taking are likely to reduce innovation. One example is corporate taxation. We developed a simple model of firms' innovation decisions to illustrate how the current asymmetric tax treatment of profits and losses influence innovation investments and industry productivity in market equilibrium. We also showed that innovation subsidies can mitigate some of the distortions caused by the tax system. In future research, it would be interesting to consider the relation between innovation employment and firm risk over firms' life-cycles. The results of the present paper already suggest that firms' average age-profit profile is systematically different for firms with different innovation employment shares. A life cycle analysis would allow us to characterize the life cycle in detail. It would also allow us to take the tax distortions into account more accurately. Such an analysis requires, however, a panel data with a longer time span than what we currently have.

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