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Imitation vs Innovation - What Makes the Difference?

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Abstract

1) State-of-the-art:
The distinction between imitation and innovation can be attained through the differentiation of product innovations into new-to-the-market innovations and new-to-the-firm innovations, where new-to-the-firm innovations are interpreted as resulting from imitating behavior (Kleinknecht et al. 2002). At the theoretical level, this distinction has been often substantiated through the analysis of the role of competition (Aghion et al. 2001, 2005).
A number of papers study the impact of knowledge spillovers (e.g., Cappelli et al., 2014) or the breadth and depth of knowledge sources on innovation and imitation (e.g., Laursen and Salter, 2006, in the context of Open Innovation).
2) Research gap:
Although recent theoretical literature has noted the importance of imitation, empirical studies explicitly dealing with the imitation-innovation antagonism are rather scarce. Furthermore, existing studies focus on particular determinants, but relatively little attention has been given to possible differences between imitating and innovating firms with respect to the whole spectrum of knowledge acquisition, i.e. different endowments with human capital, different modes of external knowledge and the ways firms acquire such knowledge.
The main objective of this paper is to identify characteristics of imitation and innovation and shed light on possible differences between these two kinds of innovative activity. It tries to answer the following questions:
1. What are the determinants of imitative performance compared to determinants of innovative performance?
2. What are the determinants of switching from imitative to innovative behavior compared to imitators and innovators showing persistence over time?
The paper contributes to existing literature in two ways: (a) the investigation is based on a comprehensive set of determinants of differences between innovators and imitators where the focus is on human capital endowment and the whole spectrum of knowledge acquisition; (b) it examines differences among groups of imitators and innovators with different time profiles with respect to persistence and continuity of innovation performance.

3) Theoretical arguments:
Based on existing literature, we test a series of hypotheses that refer to human capital endowment and modes of knowledge acquisition. For human capital endowment, the main point is that imitation and innovation require different types of human capital. Innovation might be more related to inputs from employees with tertiary-level education and imitation more to employees with vocational education. As a consequence, employees with vocational education might be relatively more productive in firms operating farther away from the technological frontier.
In-house R&D has been found a major driver of innovation (knowledge source), but it also constitutes a precondition for absorptive capacity (knowledge enabler). New knowledge generation by doing R&D might be more important for innovators than for imitators. In turn, drawing on existing knowledge through buying external R&D or R&D cooperation might be more relevant for imitators. The same can be expected for external knowledge sourcing without formal agreements that refer to technological opportunities and incoming spillovers.
4) Method and data:
In the first part of the paper, we investigate the differences with respect to the determinants of innovation performance between innovators and imitators. We use the sales share of these categories of products to measure the intensity of innovating and imitating activities, respectively, and estimate fractional logit models. Based on theoretical and empirical literature, we distinguish a number of determinants (or groups of determinants) of innovation performance that reflects the canon of determinants of innovation performance. These determinants comprise the endowment in human and physical capital; acquisition of innovation-relevant knowledge from internal and external sources (e.g. through internal and external R&D, cooperation, targeted knowledge acquisition from different partners and unspecific knowledge acquisition, appropriability conditions, and last but not least, market conditions such as demand in the product market, market structure, and intensity of market competition). In this paper, we mainly focus on the endowment in human capital and the modes of knowledge acquisition. We also test the breadth and depth measures from Open Innovation literature with our data.
In the second part of the paper, we investigate the differences with respect to the determinants of innovation performance among several groups of innovating firms that either show occasional or persistent imitative or innovative activity over time. Moreover, we investigate the switching behaviour of firms from non-innovation, imitation and innovation and conversely over time by estimating multinomial logit models. The comparison of these groups aims at refining the profiles of innovators and imitators as they emerge from the analysis in the first part of the paper.
Data is drawn from three cross-sections of the Swiss Innovation Panel (SIP), a survey very close to the CIS. It is based on a survey among Swiss firms, has taken place every three years so far and offers unbalanced panel data on innovative activities in the manufacturing and in the services sector. Switzerland might be an interesting case because it is a small economy that ranks very high in terms of innovativeness. At the same time, it is a small economy where not all sectors can be technologically leading and where imitation from foreign firms must take place.
5) Results:
We found that variables pertaining to resource endowment, technological opportunities and external knowledge acquisition are most important in explaining differences between imitation and innovation.
Our findings from econometric estimations indicate that imitating firms are significantly more extroverted than innovating firms because their activities are much more related to external R&D activities and cooperation and medium-educated personnel. Innovating firms do not rely to the same extent on the exploration of external knowledge. Their rather introverted behavior seems to be more related with intense exploitation of internal resources (own R&D and highly qualified employees). The breadth of external knowledge sources is important for imitators, whereas drawing on specific sources is not relevant. Instead, imitation is strongly related to unspecific knowledge acquisition.
Further, the profiles of different types of innovating firms show that an innovation performance hierarchy exists, ranging from occasional innovators and switchers to persistently innovating firms.
In sum, our results deliver a consistent picture of imitators vs. innovators that is more comprehensive than in other studies and deviates from existing literature with respect to some results.

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Imitation versus Innovation: What Makes the Difference?[1]

Abstract

The main objective of this empirical paper is to identify characteristics of imitation and innovation and shed light on possible differences between these two kinds of innovative activity. Thus, it tries to answer the following questions: (a) what are the determinants of imitative performance compared to determinants of innovative performance and (b) what are the determinants of switching from imitative to innovative behavior compared to imitators and innovators showing persistence over time. The study is based on Swiss firm data. In sum, our findings indicate that imitating firms are significantly more 'extroverted' than innovating firms because their activities are much more related to external R&D activities and cooperation and medium-educated personnel. Innovating firms do not rely to the same extent on the exploration of external knowledge. Their rather 'introverted' behavior seems be more related with intense exploitation of internal resources. Further, the profiles of different types of innovating firms show that an innovation performance hierarchy exists from occasional innovators, switchers to persistently innovating firms.

[1] A more detailed draft can be found at http://www.kof.ethz.ch/publikationen/p/kof-working-papers/367/. There, you can also found additional tables and an appendix not shown in this version.

1. Introduction

The distinction between 'imitation' and 'innovation' can be attained through the differentiation of product innovations into 'new-to-the-market' innovations and 'new-to-the-firm' innovations, where 'new-to-the-firm' innovations are interpreted as resulting from imitating behavior (Kleinknecht et al. 2002). Imitations are mainly incremental innovations that have to be directly related to innovations introduced by competitors.[2] At the theoretical level, this distinction has been often substantiated through the analysis of the role of competition. Aghion et al. (2001, 2005) consider the relationship between competition and innovation where imitation is necessary to escape competition. Laggard firms first need to catch up with the technological leader before racing for the next innovation. These authors find that in industries where firms are closer to the technological frontier, the escape-competition effect tends to be stronger. Zhou (2009) and Bessen & Maskin (2009) analyze imitation and appropriability conditions. Both studies come to the conclusion that weak patent protection might be superior under certain circumstances (if competition is moderate, respectively if innovation is sequential and competitors' R&D complementary to own R&D efforts) as weak protection not only leads to more imitation, but imitation also to more innovation (see also Barbosa et al. 2014 for a survey of this literature). A further theoretical branch emphasizes differences with respect to human capital endowment (Vandenbussche et al., 2006).

Although recent theoretical literature has noted the importance of imitation, empirical studies explicitly dealing with the imitation-innovation antagonism are rather scarce. Furthermore, existing studies focus on particular determinants, but relatively little attention has been given to possible differences between imitating and innovating firms with respect to the whole spectrum of knowledge acquisition, i.e. different endowments with human capital, different modes of external knowledge and the ways firms acquire such knowledge. Therefore, the main objective of this paper is to identify characteristics of imitation and innovation and shed light on possible differences between these two kinds of innovative activity. It tries to answer the following questions:

- What are the determinants of imitative performance compared to determinants of innovative performance?

[2] In contrast to radical innovations (see Dahlin & Behrens, 2005; Chandy & Tellis, 2000; Garcia & Galantone, 2002), incremental innovations are inventions that introduce concepts that are already common and can be directly derived from prior and current inventions. They do not have the potential to generate new markets, might not provide substantially higher customer benefit and are strongly influenced by past inventions.

- What are the determinants of switching from imitative to innovative behavior compared to imitators and innovators showing persistence over time?

In the first part of the paper, we investigate the differences with respect to the determinants of innovation performance between 'innovators' (INNOV: firms reporting a positive sales share with products new to the market) and 'imitators' (IMIT: firms reporting a positive sales share with products new to the firm). We use the sales shares to measure the intensity of 'innovating' and 'imitating' activities, respectively. Based on theoretical and empirical literature, we distinguish a number of determinants (or groups of determinants) of innovation performance (see Cohen 2010). They comprise the endowment in human and physical capital; acquisition of innovation-relevant knowledge from internal and external sources, appropriability conditions, and market conditions such as demand in the product market, market structure, and intensity of market competition. Our main interest lies in the endowment in human capital and the modes of knowledge acquisition.

In a second, more exploratory part of the paper, we investigate the differences with respect to the determinants of innovation performance among several groups of innovating firms that either show 'occasional' or 'persistent' imitative or innovative activity over time. We investigate the 'switching' behaviour of firms from non-innovation, imitation and innovation and conversely over time. The comparison of these groups aims at refining the profiles of innovators and imitators as they emerge from the analysis in the first part of the paper.

Data is drawn from the Swiss Innovation Panel. Switzerland is a small economy that ranks very high in terms of innovativeness (see, e.g., European Commission, 2014). At the same time, it is a small economy where not all sectors can be technologically leading and where imitation from foreign firms must take place.

The paper contributes to existing literature in two ways: (a) the investigation is based on a comprehensive set of determinants of differences between innovators and imitators where the focus is on human capital endowment and modes of knowledge acquisition; (b) it examines differences among groups of imitators and innovators with different time profiles with respect to persistence and continuity of innovation performance.

The paper is structured as follows: Section 2 reviews the literature and develops our research hypotheses. Section 3 describes the variables and econometric models. Section 4 is dedicated to the results. Section 5 concludes.

2. Literature review and research hypotheses

Based on existing literature, we formulate a series of hypotheses that we intend to investigate. Our hypotheses refer to (a) human capital endowment as measured by the share of employees with tertiary-level and upper-secondary-level education (vocational training or 'Berufslehre'), respectively; and (b) to modes of knowledge acquisition (in-house R&D, external (or contract) R&D, R&D cooperation, and use of knowledge from different external sources).

Recent studies referring to the concept of the technological frontier (see, e.g., Acemoglu et al. 2006) implicitly deal with differences with respect to human capital requirements between innovation and imitation and can yield useful insights. Starting point of Vandenbussche et al. (2006) is that imitation and innovation require different types of human capital. The authors develop a model in which the relevance of education depends on the distance to the technological frontier. In this model innovation-induced growth is driven by workers with tertiary-level education. Thus, their model would predict that employees with vocational education are relatively more productive the farther away from the technological frontier the firm operates. The hypothesis that innovation is a relatively more skill-intensive activity than imitation is supported by the empirical part of the study. At firm level, Vinding (2006) finds that the share of highly educated employees is not only positively correlated with innovation but also negatively correlated with imitation. Thus, we formulate the following hypotheses:

Hypothesis 1a: The share of highly educated employees as measured by the share of employees with tertiary education is more strongly and positively correlated with innovation than with imitation.

Hypothesis 1b: The share of medium-educated employees as measured by the share of employees with vocational education is more strongly and positively correlated with imitation than with innovation.

From Hypotheses 1a and 1b follows that innovation would be affected more than imitation by a lack of high-skilled employees:

Hypothesis 1c: Innovation is affected more strongly by a lack of high-skilled personnel than imitation.

R&D effort is most often reported as a significant determinant of innovation (Mairesse & Mohnen, 2010). In-house R&D is the most important mode of knowledge acquisition for any kind of innovative activity. It generates innovation-relevant knowledge but also constitutes a precondition for knowledge absorptive capacity (Cohen & Levinthal, 1989, 1990). Firms with

well-educated staff and permanent research activities are supposed to have higher absorptive capacity than firms lacking such characteristics.

Bessen and Maskin (2009) argue that some of the most innovative industries' products experienced rapid imitation because innovations in these industries are both sequential and complementary. They show that a firm benefits from imitation because by conducting R&D too, the imitating firm raises the probability of new invention. R&D thus fulfils two roles – as knowledge source and knowledge enabler – and is necessary for both innovation and imitation, whereas the function of new knowledge generation is likely to be more important for innovators than for imitators. There is also empirical evidence that in-house R&D is more intensive in firms that innovate than in those that imitate (Vega-Jurado et al., 2008, Barbosa et al., 2014). Thus, we expect that:

Hypothesis 2: In-house R&D activities are more strongly and positively correlated with innovation than with imitation.

New knowledge is not only generated within the boundaries of a firm but also acquired from the environment. Even the largest and most technologically self-sufficient enterprises require knowledge from beyond the firm boundaries. In addition to own research and development (internal R&D), enterprises typically are engaged in trading of knowledge on the technology market ("buy" or contract external R&D) and/or cooperate actively – formally or informally – with other firms and research institutions. Here, we concentrate on these two modes of knowledge acquisition that are based on explicit formal agreements.[4]

Dhont-Peltrault and Pfister (2011) develop the standardization hypothesis which states that R&D subcontracting is preferred over R&D cooperation when the R&D task to be performed is highly standardized. On the contrary, complex R&D tasks should be more frequently managed through formal R&D cooperation. Thus, it is reasonable to presume that R&D subcontracting is more likely to be found in imitating than in innovating firms. With respect to R&D cooperation there is mixed empirical evidence regarding the hypothesis that innovators acquire external knowledge through R&D collaborations more frequently than imitators. Tether (2002) finds that firms that conduct R&D and introduce innovations 'new to the market' rather than 'new to the firm' also engage more frequently in R&D cooperative

[4] The topic of possible complementarities among the various modes of knowledge acquisition has only recently been taken up by economic research (see, e.g., Cassiman & Veugelers, 2006). A recent study based on the same data that we use could not find any evidence for complementarity between external R&D and R&D cooperation (Arvanitis et al., 2013).

arrangements. On the contrary, Aschhoff and Schmidt (2008) find no evidence for such an effect. A possible explanation for these divergences in empirical findings could be that R&D collaborations differ significantly with respect to the type of cooperation partners. Thus, the findings that are based on an overall cooperation variable depend strongly on the composition of the collaborations with respect to the type of partners. Studies distinguishing between various types of cooperation partners (e.g., competitors, suppliers, customers, research institutions, etc.) also find mixed results but mostly of a certain pattern. Belderbos et al. (2004) explore R&D cooperation with several categories of partners. Their results confirm that objectives of R&D cooperation are quite heterogeneous. Cooperation with competitors and suppliers is focused on incremental innovations; cooperation with competitors and universities is positively correlated with innovations that are new for the market. Aschhoff and Schmidt (2008) also find that R&D cooperation with universities has a positive influence on innovation performance as measured by the sales share with market novelties, while cooperation with other firms do not show any significant effect, neither on innovation nor on imitation (both measured as in the present study). Similar effects of R&D cooperation with universities are found in a study of Monjon and Waelbrock (2003). In our sample, the largest part of the R&D cooperation projects refer to collaborations with firms, so we presume that our cooperation variable reflects primarily the influence of this type of R&D cooperation. Hence, we formulate the following hypotheses:

Hypothesis 3: External R&D is more strongly and positively correlated with imitation than with innovation.

Hypothesis 4: R&D cooperation referring primarily to cooperation with other firms is more strongly and positively correlated with imitation than with innovation.

Spillovers are a major ingredient in the process of diffusion by enabling imitation of competitors. Research also acknowledges the spillovers' role in creating new innovations. Indeed, external knowledge sourcing without formal arrangements is used by many corporations for the acquisition of knowledge that might be combined with own knowledge stocks in order to generate new products and processes. In literature, this kind of knowledge acquisition has been referred to the concept of technological opportunities (Klevorick et al., 1995) or the concept of incoming spillovers (Cassiman and Veugelers, 2002). Usually, external knowledge sourcing of this kind is operationalized with ordinal measures of the importance of various sources of external knowledge such as customers, suppliers, competitors, universities and other research institutions, publicly available knowledge, etc.

The empirical findings with respect to these single sources are mixed depending on the sample of firms on which the studies are based. Amara et al. (2005) discover that only research as a source of information shows a positive effect on innovation. Jirjahn and Kraft (2011) find positive effects for customers and competitors only for imitators. The authors conclude that "establishments exploit spillovers for incremental innovations rather than for drastic innovations" (p. 509). Cappelli et al. (2014) come to a somewhat different result: information from competitors appears to correlate positively with imitation while information from customers and information from research institutions seems to be more useful for innovators. Köhler et al. (2012) find that science-driven knowledge search is more associated with the share of sales of market novelties, while market-driven search is more related to the share of sales of firm novelties. In accordance with literature we postulate the following hypothesis:

Hypothesis 5: External sourcing is generally more useful for imitators than for innovators except for research sourcing that is more beneficial for innovators rather than for imitators.

Absorptive capacity describes the ability of a firm to apply new, external information that is critical to its innovative capabilities. A firm's absorptive capacity is a function of the firm's level of prior knowledge. This knowledge is mainly determined by a firm's R&D activity, but the stock of knowledge can be also enhanced by external sources of knowledge (Cohen & Levinthal, 1990). Building on Cohen and Levinthal, the literature on 'open innovation' argues that innovative firms draw on knowledge generated by a wide range of external sources such as customers, competitors, suppliers and universities (Laursen & Salter, 2006, p. 132; see also Chesbrough, 2003). The idea is that a firm actively searches for external knowledge and that the search process follows a 'search strategy'. Laursen and Salter (2006) do not analyze the effect of single sources of external knowledge, but rather their compound effect. For this purpose they construct two variables, breadth and depth, measuring the number of sources used and the number of sources used intensively, respectively. Their findings confirm their presumption that "searching widely and deeply across a variety of search channels can provide ideas and resources that help firms gain and exploit innovative opportunities" (p. 146), but 'oversearch' seems to negatively affect innovative performance after reaching a tipping point. External search depth is found to be more related to radical innovation than to incremental innovations. Applying knowledge from a number of external sources, a firm might be only able to introduce existing products from competitors or to improve own products rather than producing completely new products. Completely new products require rather radical changes in production modes and organizational structure (see Jirjahn & Kraft,

2006) and digging deeper into specific sources. Therefore, we formulate similar hypotheses as they do in their paper:

Hypothesis 6a: The *'depth' of external sourcing* is more strongly and positively correlated with innovation than with imitation.

Hypothesis 6b: The *'breadth'* of external sourcing is more strongly and positively correlated with imitation than with innovation.

Hypothesis 6c: The *'depth' as well as* the *'breadth' of external sourcing* shows an inverted U-shaped relationship to innovation performance for both categories.

Persistence occurs when a firm which has innovated in one period innovates once again in subsequent periods. Empirical literature on this topic is rather scarce (see, e.g., Peters 2009 for a short but comprehensive survey of related literature). Peters finds that past innovation experience is an important determinant of current innovation activities and that human capital is relevant in explaining persistence. Roper and Hewitt-Dundas (2008) find that both product and process innovation are strongly persistent and that larger plants appear to be more able in sustaining innovation than smaller plants. Woerter (2014) shows that persistence with respect to R&D expenditures is more likely to be observed in markets with few principal competitors and is very unlikely to be found in polypolistic markets. There are also studies that cannot confirm the existence of innovation persistence (Geroski et al., 1997, Raymond, 2010). Differences might be due to the innovation measures used and sectors that are covered by the data.

Here, the main idea is the differentiation of groups of firms with different patterns of innovation and imitation behavior and the investigation of possible differences with respect to innovation determinants. The interest in this issue is relevant as firms should engage in risky innovation projects persistently in order to generate new and useful products and to stimulate economic growth. Innovation-supporting policy measures will have a higher effectivity because they will affect both current and future innovation activities.

We also study firms switching from imitative to innovative behavior and the other way around as well as firms that only occasionally report sales with innovative or imitative products (see table 2 in the online working paper).

With respect to switching firms, i.e. firms switching from non-innovative activity to imitative or innovative activity or firms switching from imitative to innovative activity or conversely, existing literature does not yield any theoretical or empirical guidelines, thus the exploratory character of this part of the paper.

3. Data and variables

3.1 Data

The firm level data used in this study comes from three surveys among Swiss companies conducted in 2005, 2008 and 2011. All surveys are based on a sample which covers manufacturing, construction and services and is disproportionately stratified. In this study, we focus on manufacturing because innovations in services are different (Gallouj & Weinstein, 1997; Tether, 2001). The three surveys yielded data for 2,552, 2,141 and 2,363 firms, representing response rates of 37.9%, 36.1% and 35.9%, respectively. The cross-sections are pooled to a dataset of a total of 3,490 observations for the manufacturing sector. The final sample used for model estimation is smaller, primarily due to missing answers for some of the variables. As there is a large time lag between the surveys, only about 50% of the firms replied to two successive surveys, which means that the panel is highly unbalanced.

The three questionnaires contain questions about the firms' innovation activities, innovation success as measured by the sales share with innovations, information on the firms' resource endowment, demand and market conditions, appropriability conditions, technological opportunities and external knowledge acquisition. The surveys also collected information on some financial variables and basic structural characteristics of firms. Table 1 depicts the variables used in our estimations. Descriptive statistics and correlations can be found in table A.1 and A.2 in the Appendix of the online working paper.

3.2 Variables

As already mentioned in the introduction, our dependent variables are (a) innovation performance as measured by firm's innovative sales share of products that are 'new to the market' (INNOV) and (b) imitation performance as measured by firm's sales share of products that are 'new to the firm' (IMIT).[6]

We use a broad range of independent variables in the empirical models (see table 1). We use three different specifications for (a) and (b). They differ with respect to the modelling of the modes of knowledge acquisition and the role of knowledge sources (hypotheses 3 to 5 in section 4.1). In all three specifications we include dummy variables for external (contract) R&D and R&D cooperation and a variable that measures overall technological opportunities as they are anticipated by the firms themselves. In the first specification, we use four dummies

[6] Of course, many firms report sales for both categories of innovative products. Therefore, we cannot measure the pure effects of 'innovation' versus 'imitation' which might be the reason that not always clear-cut effects can be found.

indicating whether several knowledge sources have been used at all. We analyze the following four knowledge sources: competitors, suppliers, customers, and non-market external knowledge from institutions, universities, literature, consultants etc. In the second specification, we use four dummies indicating whether the four knowledge sources where important or very important to the firm. These dummies reflect the intensity of the use of each knowledge source. In the third specification, we apply the idea of Laursen and Salter (2006) of summarizing the number of knowledge sources a firm uses in a variable called knowledge_breadth and the number of sources that are important or very important to the firm in a variable called knowledge_depth. The values of these variables can range from zero to fourteen as there were fourteen knowledge sources in our survey, initially[7]. This approach enables a direct comparison between the 'quantity' and the 'intensity' in the use of knowledge sources. Following Laursen and Salter, we also include the quadratic terms to examine potentially curvilinear relationships with innovation performance (hypotheses 6a-6c). We used two additional specifications for each variable taking knowledge_breadth and knowledge_depth separately in order to avoid multicollinearity.

The share of employees with higher education, the share of employees with vocational training and a dummy variable for the importance of lack of qualified personnel as innovation impediment are used as proxies for a firm's human capital endowment (hypotheses 1a to 1c). In-house R&D activities are measured with a dummy variable for in-house R&D (hypothesis 2). Further, we control for gross investments per employee, share of ICT investments and the relevance of lack of funding for innovation as proxies for resource endowment besides R&D and human capital. Further controls refer to demand and market conditions (proxies for demand development, price and non-price competition intensity, the number of competitors), appropriability (measured by easiness of imitation), and general firm characteristics such as firm age, firm size and foreign ownership. To capture industry and time specific effects, we include industry fixed effects and year dummies. As already mentioned, the choice of the control variables follows theoretical literature and is in accordance with previous empirical studies[8].

In the second part of the paper, we compare firms innovating from time to time, firms innovating persistently and firms switching back and forth between imitation and innovation.

[7] In the first two specifications, we combine the 14 original single knowledge sources to four variables (e.g., suppliers of material/components, equipment and software were combined to 'suppliers').

[8] See Cohen (2010) for a review of research on innovation determinants; see Arvanitis and Hollenstein (1996) and Arvanitis (2008) for empirical studies on innovation determinants based on Swiss firm data.

The first group comprises 'occasional innovators', i.e. firms that report sales of innovative products ('new-to-the firm' or new-to the market') from time to time. The second group comprises firms that have changed from imitative to innovative behavior as measured by their sales shares with innovations resp. imitations. The third group is composed of firms that have changed in the opposite direction, namely from innovative to imitative behavior. Finally, there are also 'persistent innovators' and 'persistent imitators' comprising firms that have not changed their innovation behavior.

Based on these categories of firms we construct a nominal variable that takes the following values: 0: non-innovators, non-imitators; 1: 'occasional' innovators; 2: imitators that change to innovators as well as innovators that change to imitators ('switchers'); and 3: 'persistent innovators' or 'persistent imitators'. The three innovator/imitator groups are then compared with firms that do not report any sales of innovative products at all (persistent non-innovators) (see table 1 for the definition and table 2 in the online working paper).[9] The specification of the right-hand variables is slightly different compared to the first part: We use lagged regressors to make sure that a variable in t-1 can determine persistent or switching innovation behavior in (t-1, t) and only estimate the specification with knowledge_breadth and knowledge_depth.

3.3 Econometric issues

As our dependent variable is a proportion, we use a fractional logit model accounting for the proportional character of the dependent variable as suggested by Papke and Wooldridge (1996). In our estimations, innovation performance as reflected by the sales shares is based on the firm's decision to innovate or not. Not all firms choose to innovate so that the dependent variables are measured only for firms which actually have innovation activities. Following Egger & Kesina (2013), Oberhofer & Pfaffermayr (2009), and Ramalho & daSilva (2009), we estimate two-part models that cover the possibility that variables can affect the decision of being an innovator (activity) and the sales shares (performance) differently. The first part of the model consists of the firm's decision to innovate or not and is specified by a binary

[9] The number of switchers from imitation to innovation and conversely (n=96) is small compared to other categories (426 persistent innovators and imitators; 240 occasional innovators; 328 non-innovators). This might be due to the fact that our definition of "true" innovators allows for imitation and innovation activity at the same time, whereas our definition of imitators only allows for imitation activity. Therefore, firms are not required to really switch back and forth, but can innovate persistently with imitations and innovations at the same time. In this sense, switchers from imitation and innovation and conversely might be considered to be persistently innovating firms.

outcome model explaining the probability of a firm of being a product innovator. The decision of firm i to introduce product innovations is represented by the binary variable $innopd_i$.. Then, a logit model can be applied with cumulative logistic distribution function $\Lambda(\cdot)$:

$$\begin{aligned}\Pr(innopd_i = 1 | x_i) = \Lambda(&\beta_0 + \boldsymbol{\beta_1} \cdot resources + \boldsymbol{\beta_2} \cdot demand\_and\_market\_conditions \\ &+ \boldsymbol{\beta_3} \cdot appropriability + \boldsymbol{\beta_4} \cdot tech\_opportunities\_and\_external\_knowledge\_acquisition \\ &+ \boldsymbol{\beta_5} \cdot controls)\end{aligned} \quad (1)$$

Resources, demand and market conditions, appropriability, technological opportunities and external knowledge acquisition comprise several single variables as mentioned in section 4.2 and described in table 1. Therefore, the number of parameters to be estimated is larger as depicted in equation (1). As mentioned above, the category technological opportunities and external knowledge acquisition is specified in three different ways:

1. tech_pot, know_comp, know_supp, know_cust, rnd_coop, rnd_ext
2. tech_pot, know_comp_int, know_supp_int, know_cust_int, rnd_coop, rnd_ext
3. tech_pot, know_breadth, know_breadth2, know_depth, know_depth2, rnd_coop, rnd_ext.

The vector of controls contains firm size, age, industry and time dummies.

As shown by the aforementioned authors, the conditional mean of $inno\_share_i = \{IMIT_i, INNOV_i\}$ can be decomposed so that we can estimate both parts separately. The first part is estimated as described in equation (1). The second part of the model (for the sales shares of innovators only) is estimated with a fractional logit model, again using a logistic distribution function:

$$\begin{aligned}\Pr(inno\_share_i \mid x_i) = \Lambda(&\beta_0 + \boldsymbol{\beta_1} \cdot resources + \boldsymbol{\beta_2} \cdot demand\_and\_market\_conditions \\ &+ \boldsymbol{\beta_3} \cdot appropriability + \boldsymbol{\beta_4} \cdot tech\_opportunities\_and\_external\_knowledge\_acquisition \\ &+ \boldsymbol{\beta_5} \cdot controls)\end{aligned} \quad (2)$$

We also estimate the models jointly by pooling the data with zero product innovations and positive sales shares to test whether there are differences to the fractional response model estimated for the subsample of innovators only. Differences would indicate that the "zeroes" are determined by other variables. In our estimations, we pool the three cross sections and estimate cluster-robust standard errors. We use the GLM procedure implemented in STATA.

This procedure fits a generalized linear model where the distribution of the dependent variable and the link function can be specified.[10]

For the estimation of the equations for groups of innovators and imitators over time, we employ a multinomial logit model for the four mutually exclusive groups of firms (persistent non-innovators, occasional innovators, imitation-innovation switcher, persistent innovators or imitators) using these groups as base category, consecutively.

The findings of Garriga et al. (2013) and Laursen & Salter (2014) imply that knowledge breadth and depth must be treated as endogenous and Laursen & Salter provide evidence that external search breadth is positively associated with appropriability. Indeed, in additional regressions not shown here, we also found statistically positive associations between a variable measuring appropriability and knowledge breadth and depth. We added the fitted residual from an OLS regression on 'breadth' and 'depth' (our first stage) to the second part fractional logit model to test for endogeneity. However, this test shows that the hypothesis that knowledge breadth and depth are exogenous cannot be rejected. Our estimates include an unusually rich set of control variables. This is likely to mitigate problems of endogeneity (see also Jirjahn & Kraft, 2011, for a similar argumentation). However, it is not possible to test the existence of causal relations in our study.

4 Results

4.1 Estimates of the equations for INNOV and IMIT

The results of the fractional two-part logit model only using the subsample of firms with innovation activities are presented in table 2 and in table A.3 in the appendix of the online working paper (first part logit model for innopd). In table A.4 in the appendix, estimates of the fractional logit model using all available observations are shown, i.e. including also firms without innovation activities. We estimate average marginal effects for all estimations. For all estimations and similar to Egger & Kesina (2013), we display some criteria to evaluate the estimation quality of the model. The criteria are depicted at the bottom of the results tables.

Resource endowment

In accordance with hypothesis 2, the marginal effect of R&D is positive and significant only in the equation for INNOV. The same is true for the marginal effect of the share of employees with higher education (highly educated employees). Conversely, the share of employees with

[10] GLM does not exploit the panel structure but is rather efficient, see Papke & Wooldridge (2008).

vocational training (medium-educated employees) is only significantly associated with the sales share with imitations. These findings seem to support hypotheses 1a and 1b respectively. Impediments with respect to the endowment with skilled labor or financing (both internal and external) are not found to be statistically relevant for innovation performance. Thus, hypothesis 1c is not confirmed by these findings.

For the other variables characterizing resource endowment, only the share of ICT investments shows significantly positive associations with both dimensions of innovation performance, but to a higher degree with the sales share with imitations. The proxy for investments in physical assets (gross investment per employee) is not found to be statistically relevant for innovation performance.

Using the whole sample for estimation, R&D is found to exert a significant effect on both imitation and innovation performance (table A.4 in the online appendix). This result is obviously driven by the large effect on the probability of innovating with new products that R&D has in the first part. It supports our approach to only consider innovators in the second part, as the second part estimation might be driven by other factors than the first part. The shares of employees with higher education and with vocational training, the impediments with respect to skills and financing, and the investment variables, however, do not behave differently in the estimation for the whole sample.

Demand and market conditions

Interestingly, demand and market conditions as measured in the survey seem to play virtually no role for innovation success, except for non-price competition that has a marginal effect on INNOV that is significant on the 10% test level. In the whole sample analysis we also find significantly positive effects of a medium number of competitors in the market. This result, however, might be driven by the first part where all levels of competition exert significant effects on the probability to innovate.

Appropriability conditions

Appropriability is measured by the variable ‘easiness of imitation’, but it neither plays a role for IMIT nor for INNOV.

Technological opportunities & knowledge acquisition

Technological potential is a variable capturing the degree to which a firm draws on existing technological knowledge comprising knowledge from basic research, knowledge on key technologies and the transformation into innovations on the market, and specific knowledge

that is targeted to a certain field of activity. It is only found to be significantly related with IMIT but not with INNOV. This suggests that firms that are successful with market innovations prefer to generate new knowledge by their own rather than draw on the publicly available knowledge stock. This interpretation is underpinned by the result that R&D cooperation does play a role for IMIT but not for INNOV. The same is true for firms doing external R&D. These findings are in accordance with hypothesis 3 and hypothesis 4, respectively. To conclude, the explicit forms of knowledge acquisition (R&D cooperation; external (contract) R&D) seem to be only relevant for imitation performance. In contrast, knowledge created with own resources, i.e. by internal R&D and highly qualified employees, is relevant for market novelties.

For single knowledge sources, we find a highly significantly positive effect of the use of customers as a knowledge source on INNOV. A similar effect is also found in Cappelli et al. (2014) for German firms. No effect is found for sources other than firms (including research institutions). The use of single sources does not show significant effects on IMIT. A further test shows that the four source variables in column 1 and 2 in table 2 are jointly significant in the estimates of the innovation equation but not in the estimates of the imitation equation. Hypothesis 5 does not receive any empirical confirmation.

Contrary to single sources, the number of sources used as represented in the 'breadth' variable do matter for imitation performance which is in accordance with hypothesis 6b. We also observe a curvilinear relationship (inversely U-shaped) of this variable with respect to imitation (hypothesis 6c). This corroborates the view that imitators draw on a variety of external sources rather than targeting specific sources. This unspecific knowledge search behavior is not observed for market innovators where 'breadth' does not exert a significant effect. The effect of the overall intensity of knowledge sourcing as represented by the 'depth' variable is slightly significant for imitation performance (only the linear term). This linear term is also slightly significant for INNOV if we estimate 'breadth' and 'depth' separately. Contrary to the findings of Laursen & Salter (2006), hypotheses 6a and 6c are therefore only partly confirmed by our findings.[11]

On the whole, imitating firms seem to be significantly more 'extroverted' than innovating firms that base their activities mostly on in-house R&D and personnel with tertiary-level education. More precisely, their performance as measured by the sales share of products-new-

[11] Garriga et al. (2013) used the same source of data as we did, but considered firms from both the manufacturing and the service sector and used only one cross-section. With respect to knowledge breadth and depth their results are very similar to ours.

to-firm depends significantly on external sourcing (without any particular propensity to a specific knowledge source) and engagement in R&D cooperation and external R&D. The rather 'introverted' behavior pattern of innovating firms is more difficult to understand. Given that a firm is able to launch market novelties, it seems that its performance (as measured by the sales shares of such novelties) does not depend on the intensity of external sourcing (which does not mean that the firm does not use external knowledge at all). This finding is in accordance with a strand of literature that presumes that 'radical' innovations are not predominantly created by searching external knowledge but by an innovator's successful commercialization of a single unique idea (see, e.g., Garriga et al. 2013).

Further variables

Firm size does not seem to have an effect on our performance measures. For INNOV, we find a negative effect of firm age that is highly significant meaning that younger firms have higher sales shares of market novelties than older ones. This effect is only driven by innovative firms as can be seen from the first part of the model where firm age is insignificant. For IMIT, the effect of firm age is insignificant in all parts of the model. In most specifications, foreign ownership is positively significantly associated with the sales share with imitations, i.e. foreign-owned firms' innovation activities seem to be targeted on imitations to larger degree than domestic firms' activities.

Robustness

An important robustness check is the comparison of estimates based on the subsample for innovating firms with the estimates for the whole sample including all non-innovating firms for which both INNOV and IMIT are zero. The results show that all marginal effects that are significant for innovators only are also found to be significant in the whole sample estimation. This supports our believe that the significant marginal effects from the analysis of the subsample of innovating firms are in fact relevant and robust. Differences related to marginal effects that are only found to be statistical significant in the whole sample can be attributed to the first part, namely the decision to innovate or not (equation for innopd).

Further, GLM requires the conditional means to be specified correctly. We can test the functional form of the conditional mean by means of a link test (for details see Egger & Kesina 2013). In general, the link tests show that we do not have to worry about misspecification of the conditional means.

4.2 Estimates for groups of innovators/imitators

Table 3 contains the estimates of the multinomial logit model for the three groups of 'occasional innovators/imitators', 'switchers' between imitation and innovation and 'persistent innovators/imitators' as compared with firms without any innovative activities. We presume that there is a kind of innovation performance hierarchy that goes from occasional innovators through switchers to persistent innovating firms.

Resource endowment

R&D activities correlate more strongly with switchers and persistently innovating firms than with occasionally innovating firms. This seems to be also the case for the proxy for physical capital but not for the share of ICT investment which is more strongly positively correlated with occasional and persistent innovators (or imitators) than with switchers. Lack of funding also appears to affect occasional innovators and persistent innovators alike but not switchers. The funding requirements for these two quite different groups might be not the same: occasional innovators have to invest some resources to start innovation activities, persistent innovators need some additional investment to sustain their innovating activities, whereas switchers do not differ from non-innovators regarding the funding behavior. We find no differences among the three groups as compared with non-innovators with respect to human capital.

Demand and market conditions

Demand cannot explain differences among innovating and non-innovating firms as well as among the three groups of innovating firms. The same appears to be the case for the intensity of price competition. More intense non-price competition, however, correlates with the likelihood to innovate persistently. Market structure is not associated with the likelihood to switch, whereas it strongly correlates with the likelihood of innovating persistently or at least occasionally compared to not innovating. The effect on occasional innovative activity is strongest for a very small number of competitors (up to five) and on persistence strongest for a medium number of competitors (6-50). Persistent innovators are thus more likely to be found in markets with less than 50 competitors, i.e. in markets with moderate or strong oligopolistic structure. This finding is consistent with the results of Woerter (2014).

Appropriability conditions

A lack of protection of innovations from imitation generally affects innovative activity negatively for all three categories of innovating firms, quite in accordance with standard theoretical expectations.

External knowledge acquisition and technological opportunities

There are not any differences with respect to the anticipation of technological possibilities as measured by the variable 'technological potential' among innovating and non-innovating firms. The same is true among the three groups of innovating firms. This might indicate that information with respect to technological chances is not unevenly distributed among Swiss firms. However, there are differences with respect to the use of formal external sources of knowledge among the different groups of innovating firms and between non-innovators and innovators: First and not surprisingly, more external R&D and R&D cooperation increase the likelihood of switching and innovating persistently compared to non-innovating, but not of innovating occasionally. Second, more external R&D and R&D cooperation also increase the likelihood of switching or innovating persistently compared to innovating occasionally.

For the three groups of innovating firms that are distinguished here, the hypotheses of Laursen & Salter (2006) are only partly confirmed (but of course, they are examined in a quite different setting here). There are no differences regarding the depth of external knowledge sourcing. The expectation would be rather that this variable would increase the likelihood of persistence compared to the other two groups. Furthermore, the inversely U-shaped pattern with respect to breadth of external sourcing is only found for occasional innovators compared to non-innovators.

Further variables

There is a positive size effect on the likelihood of persistence compared to non-innovators but no age effect. Consistent with the first part of the paper, foreign ownership makes firms to be more likely to be non-innovators compared to the three groups of innovating firms.

5 Summary and conclusions

The main purpose of this paper was to characterize imitative and innovative behavior and shed light on possible differences. We analyzed a broad spectrum of possible determinants of imitation and innovation and the corresponding innovation performance. We found that variables pertaining to resource endowment, technological opportunities and external knowledge acquisition are most important in contributing to either imitation or innovation.

Internal knowledge and resources are more relevant for 'new-to-market' innovations, whereas externally acquired knowledge (including contract R&D and R&D cooperation) are more relevant for 'new-to-firm' innovations. We found that the breadth of external knowledge sources is a more important determinant of 'new-to-firm' innovation than the use of any single source or the intensity of the use of any single knowledge sources. Most important, 'new-to-firm' performance is strongly related to unspecific knowledge acquisition, namely to the so-called technological potential that is publicly available non-tacit technological knowledge.

In sum, our findings indicate that imitating firms are significantly more 'extroverted' than innovating firms because their activities are much more related to external R&D activities and cooperation and personnel with upper secondary-level education. Innovating firms do not rely to the same extent on the exploration of external knowledge. Their rather 'introverted' behavior seems be more related with intense exploitation of internal resources. In addition, firms with foreign parent company tend to perform with imitations, whereas younger firms tend to perform with market novelties.

Although the literature on the competition-innovation relationship is fruitful for the establishment of an important role of imitation with respect to innovative activity, our results do not support relationships between competition and innovation performance as measured in this study. Variables that are attached to the literature on spillovers and open innovation are found to play a more important role although our results do not coincide with former findings in every respect.

A second, more exploratory goal of the paper, was the investigation of the differences with respect to the determinants of innovation performance among three different groups of innovating firms with different innovation behavior over time ('occasional' innovators or imitators; switchers from imitation to innovation and conversely; 'persistent' innovators or imitators). The comparison of these groups aimed at refining the profiles of innovators and imitators as they emerge from the analysis in the first part of the paper. We found more differences between occasional innovators and the other two groups (switchers and persistent innovators) than between switchers and persistent innovators (as compared to non-innovators). Resource endowment (R&D, gross investment per employee) is more strongly associated with switchers and persistent innovators than with occasional innovators. Appropriability is also more important for switchers and persistent innovators than for occasional innovators. Finally, external R&D and R&D cooperation is more relevant for these

two groups than for occasional innovators. On the whole, out of these profiles an innovation performance hierarchy emerges ranking from occasional innovators through switchers to persistently innovating firms.

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Tables

Table 1: List of Variables

Variable	Description
Dependent variables	
Innopd	Firm has introduced product innovation during last three years, 1 yes / 0 no
IMIT	Sales share with product innovations new to the firm
INNOV	Sales share with product innovations new to the market
Resource endowment	
Rnd	Firm has conducted R&D during the last three years, 1 yes / 0 no (dummy variable is 0 for all non-innovators)
Lnempl_shr_higher	Share of employees with higher education, ln
Lnempl_shr_train	Share of employees with vocational training, ln
Skill_imped	Lack of skilled employees as an important or very important impediment for innovation activities, 1 yes / 0 no
Fin_imped	Lack of internal or external funding as an important or very important impediment for innovation activities, 1 yes / 0 no
Lninvest_pc	Gross investments per employee, ln
Lnict_inv_share	Share of ICT investments in total investments, ln
Demand and market conditions	
Demand	Assessment of demand development on prime market, average for the period 2009-2014, -2 strong decrease / 2 strong increase
Price	Strong or very strong price competition on prime market, 1 yes / 0 no
Nprice	Strong or very strong non-price competition on prime market, 1 yes / 0 no
N_compet_1	Number of main competitors <=5, 1 yes / 0 no
N_compet_23	Number of main competitors 6 to 15, 1 yes / 0 no
N_compet_4	Number of main competitors 16 to 50, 1 yes / 0 no
Appropriability conditions	
Copy_imped	Innovations can be easily copied, 1 yes / 0 no
Technological opportunities & external knowledge acquistion	
Tech_pot	Technological potential, i.e., technological knowledge which is available worldwide and can be used for the creation of novelties, high or very high, 1 yes / 0 no
Know_comp	Knowledge source competitors used, 1 yes / 0 no
Know_supp	Knowledge source suppliers used, 1 yes / 0 no

Know_cust	Knowledge source customers used, 1yes / 0 no
Know_external	Knowledge source research institutions, universities, consultants, technology transfer or other external sources that are open to general public used, 1 yes / 0 no
Know_comp_int	Knowledge source competitors important or very important, 1 yes / 0 no
Know_supp_int	Knowledge source suppliers important or very important, 1 yes / 0 no
Know_cust_int	Knowledge source customers important or very important, 1 yes / 0 no
Know_external_int	Knowledge source research institutions, universities, consultants, technology transfer or other external sources that are open to general public important or very important, 1 yes / 0 no
Know_breadth	Number of knowledge sources used
Know_depth	Number of knowledge sources that are important or very important
Know_breadth2	know_breadth squared
Know_depth2	know_depth squared
Rnd_coop	R&D cooperation during the last three years, 1 yes / 0 no (dummy variable is 0 for all non-innovators)
Rnd_ext	External R&D, 1 yes / 0 no (dummy variable is 0 for all non-innovators)
Controls	
Lnempl	Number of employees, ln
Lnage	Firm age, ln
Foreign_owned	Firm owned by foreign company
Multinomial variable	
Value 0	Non-innovating, non-performing firms (i.e. firms without sales of innovative products; INNOV=0 & IMIT= 0) in every period
Value 1	'Occasional' innovators or imitators (i.e. INNOV=0 & IMIT=0 → INNOV>0 & IMIT>=0 resp. INNOV=0 & IMIT=0 → INNOV0 & IMIT>0 and the other way around: INNOV>0 & IMIT>=0 → INNOV=0 & IMIT=0 resp. INNOV=0 & IMIT>0 → INNOV=0 & IMIT=0)
Value 2	'Switchers': Imitators that change to innovators (i.e. INNOV=0 & IMIT>0 → INNOV>0 & IMIT>=0); Innovators that change to imitators (i.e. INNOV>0 & IMIT>=0 → INNOV=0 & IMIT>0)
Value 3	'Persistent innovators' or 'persistent imitators' (i.e. INNOV>0 & IMIT>=0 → INNOV>0 & IMIT>=0 resp. INNOV=0 & IMIT>0 → INNOV=0 & IMIT>0.

Table 2: Marginal effects from fractional logit models, IMIT and INNOV, innovators only

	innovators only									
	IMIT	INNOV	IMIT	INNOV	IMIT	INNOV	IMIT	INNOV	IMIT	INNOV
Rnd	0.002	0.039***	0.004	0.041***	0.000	0.041***	0.001	0.042***	0.000	0.041***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Lnempl_shr_higher	-0.002	0.009*	-0.002	0.010*	-0.003	0.008	-0.003	0.008	-0.003	0.008
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Lnempl_shr_train	0.012*	0.005	0.012**	0.005	0.011*	0.004	0.011*	0.004	0.011*	0.004
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Skill_imped	0.014	-0.014	0.014	-0.012	0.011	-0.012	0.012	-0.011	0.012	-0.011
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fin_imped	-0.004	-0.003	-0.005	-0.004	-0.004	-0.004	-0.004	-0.005	-0.003	-0.004
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Lninvest_pc	-0.001	-0.003	-0.001	-0.003	-0.001	-0.004	-0.001	-0.004	-0.001	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lnict_inv_share	0.013**	0.008*	0.012**	0.009**	0.012**	0.007*	0.013**	0.008*	0.013**	0.008*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Demand	0.007	0.002	0.007	0.002	0.008	0.001	0.008	0.001	0.008	0.001
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Price	0.007	0.004	0.006	0.004	0.004	0.001	0.006	0.003	0.004	0.001
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Nprice	0.004	0.014*	0.003	0.014*	0.003	0.013*	0.004	0.014*	0.003	0.013*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N_compet_1	-0.012	0.005	-0.011	0.007	-0.013	0.004	-0.013	0.004	-0.013	0.004
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N_compet_23	0.004	-0.002	0.005	-0.002	0.002	-0.004	0.002	-0.004	0.002	-0.003
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N_compet_4	0.017	-0.005	0.018	-0.004	0.013	-0.005	0.014	-0.005	0.013	-0.005
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Copy_imped	0.000	-0.011	-0.002	-0.008	-0.003	-0.010	0.000	-0.008	-0.003	-0.010
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tech_pot	0.032***	0.009	0.029***	0.009	0.026***	0.008	0.030***	0.01	0.025***	0.007
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rnd_coop	0.021**	-0.001	0.021**	-0.001	0.019**	-0.002	0.021**	0.000	0.019**	-0.002
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rnd_ext	0.015*	0.006	0.015*	0.007	0.017**	0.005	0.018**	0.006	0.016*	0.005
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Know_comp	-0.018	-0.017								
	(0.01)	(0.01)								
Know_supp	0.001	0.005								
	(0.01)	(0.02)								
Know_cust	0.022	0.044***								
	(0.02)	(0.02)								
Know_external	0.008	0.019								
	(0.01)	(0.01)								
Know_comp_int			0.001	-0.01						
			(0.01)	(0.01)						
Know_supp_int			0.019*	0.016						
			(0.01)	(0.01)						

Know_cust_int			0.001	0.007						
			(0.01)	(0.01)						
Know_external_int			0.006	-0.017						
			(0.02)	(0.01)						
Know_breadth					0.012*	0.006	0.014**	0.008		
					(0.01)	(0.01)	(0.01)	(0.01)		
Know_breadth2					-0.001**	0.000	-0.001**	0.000		
					(0.00)	(0.00)	(0.00)	(0.00)		
Know_depth					0.007*	0.006			0.008*	0.007*
					(0.00)	(0.00)			(0.00)	(0.00)
Know_depth2					0.000	0.000			-0.001	-0.001
					(0.00)	(0.00)			(0.00)	(0.00)
Lnempl	-0.004	0.004	-0.005	0.005	-0.004	0.006*	-0.004	0.006*	-0.006*	0.006*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lnage	-0.005	-0.018***	-0.004	-0.018***	-0.004	-0.016***	-0.004	-0.017***	-0.004	-0.017***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
Foreign_owned	0.017	-0.016	0.018*	-0.014	0.020**	-0.016*	0.021**	-0.015	0.019*	-0.016*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industry dummies						included				
Year dummies						included				
AIC	0.683	0.653	0.683	0.654	0.681	0.648	0.680	0.646	0.680	0.646
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ll	-578.715	-551.573	-578.769	-552.145	-605.158	-573.669	-605.651	-573.954	-605.717	-573.788
N	1823	1823	1823	1823	1906	1906	1906	1906	1906	1906

* p<0.10, ** p<0.05, *** p<0.01

cluster robust standard errors in parentheses

Table 3: Multinomial logit models, switcher and persistent innovators

	non-innovators base category	INNOV or IMIT from time to time	switcher IMIT <=> INNOV	persistent IMIT or INNOV
Lrnd		1.766***	3.566***	3.357***
		(0.36)	(0.55)	(0.40)
Llnempl_shr_higher		0.099	-0.044	0.009
		(0.11)	(0.19)	(0.15)
Llnempl_shr_train		-0.174	-0.226	0.02
		(0.18)	(0.23)	(0.20)
Lskill_imped		-0.324	-0.085	-0.542
		(0.32)	(0.41)	(0.36)
Lfin_imped		-0.761**	-0.757	-0.809**
		(0.31)	(0.47)	(0.40)
Llninvest_pc		0.177***	0.245*	0.264***
		(0.07)	(0.13)	(0.08)
Llnict_inv_share		0.215*	0.029	0.254*
		(0.12)	(0.20)	(0.15)
Ldemand		-0.163	-0.208	0.193
		(0.15)	(0.25)	(0.19)
Lprice		-0.037	-0.357	-0.137
		(0.22)	(0.35)	(0.27)
Lnprice		0.308	0.198	0.523*
		(0.24)	(0.33)	(0.28)
Ln_compet_1		1.179***	0.899	1.362***
		(0.35)	(0.60)	(0.45)
Ln_compet_23		0.862***	0.729	1.274***
		(0.33)	(0.56)	(0.42)
Ln_compet_4		0.66	0.754	1.137**
		(0.42)	(0.67)	(0.54)
Lcopy_imped		-0.604**	-0.890**	-1.053***
		(0.25)	(0.37)	(0.30)
Ltech_pot		-0.24	0.046	-0.038
		(0.30)	(0.38)	(0.31)
Lknow_breadth		0.300**	0.191	0.167
		(0.13)	(0.26)	(0.20)
Lknow_breadth2		-0.020***	-0.012	-0.009
		(0.01)	(0.01)	(0.01)
Lknow_depth		0.184	0.252	0.101
		(0.12)	(0.17)	(0.14)
Lknow_depth2		-0.011	-0.022	-0.004
		(0.01)	(0.02)	(0.02)
Lrnd_coopi		1.072	1.511**	1.259*
		(0.68)	(0.70)	(0.67)
Lrnd_exti		0.681	1.549***	1.160**

		(0.50)	(0.57)	(0.50)
Llnempl		0.153	0.231	0.278**
		(0.11)	(0.15)	(0.12)
Llnage		0.061	0.327	0.15
		(0.14)	(0.23)	(0.18)
Lforeign_owned		-1.005***	-1.277***	-1.129***
		(0.34)	(0.49)	(0.38)
Industry dummies		included		
Year dummies		included		
Constant		-4.297***	-7.654***	-9.210***
		(1.30)	(2.06)	(1.64)
Pseudo R-squared	0.32			
Prob > chi2	0.00			
ll	-879.591			
N	994			

* p<0.10, ** p<0.05, *** p<0.01