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The influence of industry downturns on the propensity to innovate

Luca Berchicci
Rotterdam School of Management
Strategic Management & Entrepreneurship
lberchicci@rsm.nl

Christopher Tucci
EPFL

christopher.tucci@epfl.ch

Cristiano Zazzara
École Polytechnique Fédérale de Lausanne
CdM-CSI
cristianozazzara@yahoo.com

Abstract

This paper tries to shed light on how industry fluctuations affect firms? propensity to innovate. We test two conflicting arguments that suggest how firms are more or less inclined to engage in innovative activities during industry fluctuations. By studying a panel of 622 Italian manufacturing firms during the period 1995-2003, we show how differentiating between product and process innovation may help reconcile the theory of opportunity cost of innovation with the cash-flow effect argument. We find that industry downturns are related to product and process innovation in different ways: firms tend to invest in product innovation rather than process innovation in downturns. The findings have implications for both theory (showing when the opportunity cost of innovation dominates) and research design (showing the importance of both the input and output measures in innovation studies and how they might influence the results).

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Abstract

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Keywords: Product Innovation, Process Innovation, manufacturing, industry downturns, industry fluctuations.

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1. Introduction

The global economic crisis of 2008-2009 has shown once again how environmental factors and market changes seriously influence industry dynamics and firm strategy. How firms react and respond to industry changes and fluctuations by adapting their innovation strategies is still a relevant question both for scholars and practitioners. The main purpose of this study is therefore to identify how certain environmental factors influence the innovative behaviour of manufacturing firms. In particular, we focus on how industry downturns influence manufacturing firms' realisation of innovative activities.

Previous research has attempted to explain and predict the relationship between industry fluctuations or market changes and firms' propensity to innovate. On one hand, the theory of opportunity costs of innovation predicts that in an industry downturn, firms tend to invest in innovative activities due to the diminished rents of existing activities (Geroski & Walters, 1995). On the other hand, the cash flow effect argument suggests that firms tend to retrench innovative activities during industry downturns due to the limited resources and perceived high risk of innovative undertakings. So far, the empirical evidence has been ambiguous. Some scholars find a positive relationship between industry downturns and innovation activities (Nickell, Nicolitsas, & Patterson, 2001, process innovation only), others find non-existent associations (McGahan & Silverman, 2001; Saint-Paul, 1993), while still other researchers argue that positive business or industry fluctuations trigger innovative activities (Geroski & Walters, 1995).

We test these seemingly competing arguments by investigating how industry downturns influence firms' propensity to engage in product and process innovations by using data from a well-known Survey on Italian Manufacturing Firms (SIMF).

Our research advances the literature in two ways. First, our results suggest that theories that try to explain firm's innovation propensity need to clearly separate the influence of environmental factors on product vs. process innovation. Our findings suggest that during industry downturns Italian manufacturing firms engage in product innovation while holding back on process innovation. We provide a novel theoretical explanation by bridging opportunity cost theory with the cash flow effect argument. Second, we show how spurious results may be generated by lumping product and process innovation together. We suggest that previous ambiguous results may be due to the heterogeneous effects of industry fluctuations on the types of innovation; in other words, when different measures of innovation are used (some process, some product, some combination of the two), it is difficult to predict in which direction different environmental factors will work. As a number of empirical studies use proxies of innovation activities without clearly distinguishing the type of innovation, these practices may contribute to a lack of uniform results in the literature.

The paper is organized as follows. First, we provide definitions of product and process innovations. Second, a brief review of the literature is presented and finalized by proposing two sets of conflicting hypotheses. Next, we provide the survey data used for this study and a description of the empirical models used for the analysis. After reporting and discussing the results, we conclude the paper by emphasizing its contribution and stating its limitations.

Theory and hypotheses

Product and process innovation

The importance of innovation as a crucial means to create and maintain economic growth and sustainable competitive advantage has been largely acknowledged (e.g. Drucker, 1985; Schumpeter, 1934). Schon (1967) describes the corporation as a miniature nation where the weapons are products and processes, its battlefield is the market place and innovation is essential to engage in this "war." Nevertheless, there is no consensus in defining "innovation" exclusively (for a review see Garcia & Calantone, 2002). A general and early definition of innovation is that of Schumpeter: "*the commercial or industrial application of something new—a new product, process or method of production; a new market or source of supply; a new form of commercial, business or financial organization*" (Schumpeter, 1934: 73). Starting from this definition, we generally refer to two distictive innovative activities of a firm: product and process innovation. The former usually refers to a new product, invention or artifact that is introduced into the market and put into use (Garcia & Calantone, 2002; Schon, 1967). The latter is defined as new factors introduced into an organization's production—systems and equipment to produce a product—to increase product quality or to reduce production costs (Damanpour, 1991; Pisano, 1990; Reichstein & Salter, 2006).[1] How industry downturns might affect the propensity of firms to engage in either product or process innovation is the aim of the next section.

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[1] The abovementioned definition does not specify to what extent something is considered new and new to whom. The degree of the newness, usually expressed as innovativeness, and the magnitude of the unit of adoption cause innovations to be perceived differently. The discussion on the degree of newness is beyond the scope of this paper.

Industry level fluctuations

Previous research has investigated how firms innovate in different phases of industry cycles (e.g. Windrum, 2005). Theory suggests and empirical evidence demonstrates that product innovation is the predominant form of innovation when an industry emerges and grows, while in the mature, declining, and / or "systemic" phase of an industry, the dominant form is the process innovation (Abernathy & Utterback, 1978; Anderson & Tushman, 1990; Gort & Klepper, 1982; Jovanovic & MacDonald, 1994; Klepper, 1997; Suarez & Utterback, 1995). At the industry level, cycles occur during a long period of time, where an emergent phase is followed by a phase of growth and finally by maturity and decline (Gort & Klepper, 1982; Jovanovic & MacDonald, 1994). These cycles are rarely repetitive in a single industry since an industry phase may last for years if not decades.

Rather than on long-term industry cycles, the focus of this paper is on shorter-term *industry fluctuations*. We define industry fluctuations as changes in demand occurring within a one- to three-year period during which the industry may experience downturns or upturns. These industry fluctuations can be repetitive in a single industry. For example, the software industry experienced industry fluctuations in terms of rapid growth in number of firms and in demand in the late 1990s, followed by a period of decline (the bursting of the dot.com bubble). From an industry cycle perspective, however, the software industry has experienced a phase of sustained growth during the last decades. Our definition of industry fluctuations is similar to business cycles in a specific industry context. The difference resides in the unit of analysis. While business cycles usually capture changes in the overall economy, industry fluctuations are industry-specific—changes in demand within industry sectors.

Therefore this paper attempts to answer the question: how do industry downturns influence a firm's propensity to innovate? We assume a "demand pull" perspective where changes in the environment (industry fluctuations) affect this propensity (Scherer, 1982;

Schmookler, 1966). As Geroski & Walter (1995) demonstrate in their work, there could be a causal relationship between industry fluctuations and innovative activities (and not vice versa). From this perspective, there are two conflicting arguments that state the type of relationship between industry fluctuations and innovative activities.

The first argument is based on the *opportunity cost of innovation*. As explained by Geroski & Walters (1995), during a cyclical downturn the rents from a firm's current activities usually decrease (Arrow, 1962) and if this loss is larger than the relative returns to be gained from implementing new products or processes, firms have incentives to introduce new innovations (Geroski & Walters, 1995; Saint-Paul, 1997). Moreover, as environmental conditions change, firms need to re-allocate and divert resources strategically by changing current activities or structures and setting new activities (Hall, 1991b; Penrose, 1959). A downturn in an industry could trigger firms to restructure their relatively less profitable activities (Kleinknecht, 1984). For example, Hall (1991a) suggests that firms invest in innovative activities and redeployment of organizational resources when there is a contraction in demand. These scholars suggest a counter-cyclical argument that implies a positive relationship between an industry downturn and innovative activities.

A second argument, contrary to the first one, is based on the *cash-flow effect.* Industry downturns reduce cash-flow and make it difficult for a firm to finance and invest in new innovative activities. On the contrary, favourable market conditions, increased profitability, deep cash flow, and greater demand imply greater incentives for firms to engage in innovation activities. For example, prior research on R&D output emphasizes this pro-cyclical behaviour (Himmelberg & Petersen, 1994). Others argue that firms introduce new technologies in upturns in order to capture high profits (Shleifer, 1986). Further, firms may be more able to appropriate the rents from product innovations when market conditions are more favourable. This second perspective suggests that there is a negative relationship between an industry downturn and innovation activities.

Previous empirical reseach has focused on the relation between business cycles and productivity growth yet has rarely studied the relation between industry fluctations and innovation activities, and the limited evidence has shown unclear findings. For example, Nickell, Nicolitsas, & Patterson (2001) find that UK manufacturing firms introduce productivity-improving innovations during downturns. On the other hand, Geroski and Walter (1995) find that industry fluctuations positively influence innovation activities by studying UK patents and innovation over a 40-year period. Looking at U.S. firm R&D expenditures during the period 1956-96, Rafferty (2003) seems to confirm pro-cyclical behaviour. However, Saint-Paul (1993: 880) finds "very little evidence of any pro- or countercyclical behaviour" of R&D activity (measured by R&D expenditures). Taking a longer view of the cycles, McGahan and Silverman (2001) attempt to link different industry cycles and different types of innovation. By examining various industries over a 13-year time period, they claim that there is not a significant difference between innovative activities in mature and emerging industries.

Given the lack of clear empirical evidence, we are agnostic on which approach has more explanatory power. Therefore, we put forward two sets of conflicting hypotheses based on the two above arguments on the effect of industry downturn on a firm's propensity to engage in product innovation and process innovation respectively. Table 1 presents the outline of these arugments.

***** Please insert Table 1 about here *****

Opportunity cost effect and product innovation

According to the first argument, and as depicted in the upper left quadrant of Table 1, engaging in innovation activities has lower opportunity costs during an industry downturn than it would be during an upturn due to the lower returns from existing products. Moreover, it is likely that firms have excess capacity—in terms of manufacturing, labor, and distribution—that in turn could provide an incentive to deploy current underutilized resources for new product innovation at lower marginal costs. Given the lower value of the current product set, firms could engage in new product innovation to explore new markets or market niches where demand might be growing and to diversify their product portfolio while reducing the risk of persisting decreasing returns. Furthermore, engagining in new products could give those firms the opportunity to have an advantage when demand increases later on. According to this argument, one would expect that:

H1a: *there is a positive relationship between an industry downturn and firms' propensity to engage in product innovation*.

Cash flow effect and product innovation

From the second argument (lower left quadrant of Table 1), one would expect that during an industry downturn, firms are constrainted in their financial resource and are less prone to engage in product innovation activities. Moreover, since the duration and persistence of the downturn are not well known, firms are uncertain about future development and may tend to postpone any decisions in product innovation investment. Due to lower demand, firms could perceive product innovation a very risky undertaking because it requires confidence in consumer demand. According to this logic, one would expect that they would tend to retrench:

H1b: *there is a negative relationship between an industry downturn and firms' propensity to engage in product innovation*.

Opportunity cost effect and process innovation

As shown in the upper right quadrant of Table 1, innovations that enhance production activities could have an important role during industry downturns as a result of intertemporal substitution[2] between process innovations and directly productive activities. In other words, since the returns from productive activities are lower due to lower demand, the opportunity cost of forgone profits from these activities is lower during industry downturn. Therefore, productivity-improving activities could provide firms with cost advantages when demand recovers. Furthermore, process innovation could positively influence firms' profitability in a downturn. Assuming the existence of low hanging fruit opportunities, process innovations that involve cost-saving and productivity-enhancing activities could allow firms to reap profits despite the lower demand, thus implying:

H2a: *there is a positive relationship between an industry downturn and firms' propensity to engage in process innovation*.

Cash flow effect and process innovation

Finally, as depicted in the lower right quadrant of Table 1, due to lack of slack financial resources, firms may decide not to engage in process innovations to improve a current set of products whose values are depreciated. In this case, process innovations could have a low return on investment due to the low demand of existing products. Moreover, when demand expands again later on, new market areas could be more attractive making existing products obsolete. Any investment to enhance the productivity of current products could run the risk of being lost as these products may not meet future demand. This would leave one to conclude:

H2b: *there is a negative relationship between an industry downturn and firms' propensity to engage in process innovation*.

[2] The process of maximizing utility by allocating resources across time.

Method

The data for this study on innovation activities in the manufacturing sector come from the Surveys of Italian Manufacturing Firms (SIMFs) run by the Research Department of Capitalia Banking Group.[3] The first survey was conducted on a random sample of firms in 1992 (covering the period 1989-1991), the second survey in 1995 (covering 1992-1994), the third survey in 1998 (covering 1995-1997), the fourth survey in 2001 (covering 1998-2000), and the latest one in 2004 (covering the period 2001-2003).[4] For reasons of consistency of questions asked in the survey, in this study, we focus on the 1998, 2001 and 2004 surveys.[5]

The questionnaire and methodology for the survey related to the innovation & technology section is similar to that adopted for the Community Innovation Survey (CIS). In the questionnaire, firms are asked whether they innovate or not based on definitions of innovation that involve product innovation, process innovation, organizational/operational innovations related to products, and organizational/operational innovations related to processes.

The SIMF is an unbalanced dataset, since a small number of firms did not continue to provide information from one three-year "wave" to the next for several reasons (mergers, changes to non-manufacturing activity, non-response [e.g., too busy] or ceasing production). New companies were included in the Survey each wave in an attempt to maintain representativeness. After eliminating a small number of observations due to inconsistencies in the data, we have a panel with 622 firms that are present for at least 2 consecutive waves, for a total of 1,795 observations over the period 1995-2003 (93% of firms are present in every

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[3] On October 1, 2007, Capitalia was acquired and merged into Unicredit Group, one of the largest banks in the world. As of January 15, 2007, Unicredit ranked first in Italy, third in Europe, and sixth in the World in terms of market capitalization (*Source*: *Thomson Financial*).
[4] This latest Survey expanded industry coverage to include services, construction, and electricity as well.
[5] The SIMF is being used by an increasing number of scholars (e.g. Hall, Lotti, & Mairesse, 2008).

wave).[6] Using this dataset, we are able to use panel data techniques and carry out analysis of dynamic models. To date, few studies have undertaken such an analysis in the innovation literature, probably due to the lack of availability of times series data in many countries.

We also use data from ISTAT (Italian National Institute of Statistics), a public research organization and the main producer of official statistics since 1926. We were able to retrieve information about industrial production from each industry manufacturing sector as well as on imports and exports. Next, we use data from "Movimprese" a database managed by Infocamere, the Association of the Italian Chamber of Commerce. This dataset reports the total number of firms in each industry each year. Furthermore, the estimates of the concentration index are based on revenue (turnover) figures for each firm obtained from the AIDA database,[7] and are referenced to the year 2003. Table 2 illustrates the industries present in the panel, their Herfindal-Hirschmann Index, the number of firms in each industry and their propensity to innovate.

***** Please insert Table 2 about here *****

Over the 1995-2003 period, 64% of firms surveyed engaged in innovative activities, whether product or process innovation. The rate of product innovation was about 14%, while that of process innovation was circa 25% (the rate of those who performed both product and process innovation was about 25%). These firms represent 19 "industries" (at the two-digit level of the ATECO 1991 classification system)[8] in the manufacturing sector. The majority of the firms come from the industries "Machinery and Equipment," "Fabricated Metal Products, Except Machinery and Equipment," "Food Products and Beverages," and "Textiles," which together account for almost 50% of the entire sample (Table 2).

[6] Excluding those firms that are not in every wave does not change the results reported below.
[7] This is a product by Bureau Van Dijk that contains financial information (in the form of company accounts, ratios, activities, ownership, subsidiaries, and management) on 280,000 Italian companies.
[8] The Italian version of the North-American Industry Classification System (NAICS) or the European NACE classification.

Table 3 displays a description of the variables used in the study, together with summary descriptive statistics. We also have dummy variables for each wave of the surveys, (not reported in Table 3). Below we provide detailed information on these variables.

***** Please insert Table 3 about here *****

Measures

Dependent variables

In the SIMF questionnaire, firms are asked about their innovative activities and output. They needed to indicate whether they engaged in new or significantly improved product or process innovations and any organizational/operational innovations related to these innovations.[9] Based on these questions, we constructed three dependent variables – "*innovation*", "*product innovation*" and "*process innovation.*" The former is equal to 1 if the firm developed any type of innovation, whether product or process innovation, zero otherwise. This variable is used in our basic model in our analysis. The *product innovation* variable takes a value equal to 1 if the firm developed a product innovation or organizational/operational innovation related to product innovation, zero otherwise. The *process innovation* takes a value equal to 1 if the firm developed a process innovation or organizational/operational innovation related to process innovation, zero otherwise.

Independent variable

To measure industry fluctuations and specifically industry downturns, we use industrial production data. Industrial production offers a convenient way to proxy demand since industrial production changes are very sensitive to changes in consumer and supply demand (Gehman & Motheral, 1968). Industrial production is a measure of change in output for industrial sectors in the economy. We retrieved industrial production data for each of the

[9] The actual questions were (translated from Italian): "Within the last 36 months, has your firm introduced any product innovations?" "Within the last 36 months, has your firm introduced any process innovations?" etc. Thus the respondent himself or herself selects the appropriate response(s).

industry categories in our sample (at the two digit level). Table 4 shows the growth rate of industrial production per industry sector over the sample period. The *industrial production downturn* variable is the inverse growth rate of industrial production over each three-year survey period. As a robustness test, we also use a dichotomous version of the industrial production downturn. It takes value equal to 1 if the firm belongs to an industry sector that experiences an industrial production downturn, 0 otherwise. Table 4 also shows the growth rate in the number of firms per Industry sector over the sample period. This variable is explained further and employed in the robustness test section.

***** Please insert Table 4 about here *****

Control variables

For control variables, we take into account firm characteristics, as well as other environmental factors that may influence the firm's innovative activities. We control for firm characteristics, mainly the *age* and the *size* of the firm, and a firm's propensity to engage in R&D. The *age* of the firm is equal to the log of the number of years since the date of establishment. The *size* of the firm is expressed by the log of the number of employees in a given year. We control for investments in Research and Development activities as well. *R&D* is equal to 1 if the firm performs R&D activities. We also include region-level characteristics. *South*, dummy variable equal to 1 if the firm is located in the Southern regions of Italy. According to the SIMF classification, we select firms located in the following regions: Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia, Sardinia, and Sicily. Since most of the Italian manufacturing firms are located in the Northern part of Italy, this variable takes into account regional differences, which has been found to be important for innovative activities (Roper, Love, Ashcroft, & Dunlop, 2000; Sternberg & Arndt, 2001).

We include three industry factors. First, *HHI* is represents the value of the Herfindhal-Hirschmann Index (the scale adopted for the Index is from 0.0 to 1.0, where a 1.0 is obtained in the case of a monopoly). For each industry, we first calculated the market share of each firm as the ratio between the firm's sales (turnover) and total industry sales, and then we estimated the Herfindhal-Hirschmann Index:

$$\text{HHI} = \sum_{i=1}^{N} s_i^2 \qquad [1]$$

where s_i is the market share of firm i and N is the number of firms. Thus, HHI is the sum of the squared market share of each firm in the industry at issue (see Table 2). The HHI is influenced by the relative market share of each firm in the industry (the higher the market share of one firm, the more concentrated the industry) and by the number of firms in the industry (the higher the number of competitors in a particular industry, the less concentrated the industry).

Second, we include *China import* that captures the change in imported goods from China across our time period per industry sector. This variable attempts to control for increasing competition in manufacturing from Chinese companies. Stronger competition from China could force Italian firms to withdraw from process innovation while focusing on activities for new product introductions.[10] Third, each model includes dummy variables for every industry sector at the two-digit level.

4. Analytical procedures

We follow the conventional practice of using a discrete and limited dependent variable model[11] to analyze the determinants of innovation. The probability to innovate is modeled as:

$$y_{it} = \mathrm{X}_{it}\beta' + \mu_{it} \qquad [2]$$

[10] We would like to thank one of our anonymous reviewers for suggesting this idea.

[11] For an excellent review of regression models for categorical and limited dependent variables, see Long (1997).

where:

$$y_{it} = \begin{cases} 1 & \text{if } y_{it} > 0\text{, i.e. firm } i \text{ innovates in a given period } t \\ 0 & \text{otherwise} \end{cases} \quad [3]$$

and X_{it} is the set of exogenous (independent) explanatory variables and μ_{it} the error term. The probability of innovation is modeled as a probit model.

We develop our analysis building a model for each definition of innovation, where the independent variables are chosen according to existing studies at a similar level of analysis:

INNOVATION = f(*Firm, Industry, Region, Other Controls*) [4]

PRODUCT INNOVATION = f(*Firm, Industry, Region, Other Controls*) [5]

PROCESS INNOVATION = f(*Firm, Industry, Region, Other Controls*) [6]

where INNOVATION is the probability of a firm innovating; PRODUCT INNOVATION and PROCESS INNOVATION are the probabilities of a firm innovating in product or in process respectively. The econometric treatment takes into account (1) that the dependent variable is binary, and (2) that we have panel data. Thus we use "random effects" probit models to control for unobserved heterogeneity.[12]

Results

Table 5 reports the results of the random effects estimations. In Model 1 our dependent variable is "innovation." We find that *R&D* and *size* are positively associated with innovative

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[12] We also used other specifications, including a conditional logit model with firm fixed effects, which found even stronger results but with a greatly reduced number of observations due to the lack of variables changing values over the course of the panel.

activities. These findings suggest that firms that perform R&D as well as large ones have a stronger tendency to engage in innovative activities (than non-R&D-performers and smaller firms, respectively). We do not find that firm *age* and regional characteristics (*South*) nor *China import* influences the propensity to innovate. Turning to our variable of interest we observe that there is no apparent relationship between industrial production downturns and firms' innovative activities.

***** Please insert Table 5 about here *****

The dependent variable in Model 2 is "product innovation," while in Model 3 it is "process innovation." And the effect of our main independent variable is significantly different in both models. In Model 2, we find that a period of decline in industrial production does influence the firm's propensity to engage in *product* innovation. On the contrary, Model 3 shows that, under the same industry conditions, firms engage in fewer process innovations. These results suggest a negative association between industrial production downturns and process innovations. Overall, firms developing new processes require brighter economic prospects to extract results. An industry downturn may trigger firms in that industry to find new product opportunities. These results are consistent with both Hypotheses 1a and 2b. They confirm H1a because we find that there is a positive relationship between greater industrial production downturn and firms' propensity for *product* innovation. They confirm H2b by suggesting that downturns are negatively associated with firms' propensity for *process* innovation.

Furthermore, these findings seem to suggest that the significant and opposite effects of a period of decline on product and process innovation are concealed and become insignificant when product and process innovation are grouped together.

Turning to the control variables, we find that *China import* has a positive and statistically significant association with product innovation (but no association with process innovation). This effect could suggest that greater Chinese competition drove Italian companies to focus their efforts in new product development activities. Or, finding themselves often as suppliers, Chinese companies deliver goods to sustain new product development of Italian firms.

Robustness checks

To test whether our results were robust, we ran several additional tests. First, we used two alternative methods to measure industry downturns. We used a dichotomous version of our industrial production downturn variable. Following the same estimation models and methods shown in Table 5, Models 1 to 3 in Table 6 show very similar results. In Model 1, there is no apparent influence of industry downturns on the firm's propensity to engage in overall innovative activities. However, when we differentiate between product and process innovation, again we find significant results. The probability to engage in product innovation shows an increase of 6% during an industrial production downturn, while the likelihood to develop a process innovation decreases by 8%.

***** Please insert Table 6 about here *****

Our second approach seeks to find a more conservative measure of industry downturns. We do so by combining the industrial production downturn with the number of firms in a given industry. When both industrial production and number of firms decline in a given period, we would expect a stronger effect of this combined industry downturn measure on a firm's propensity to engage in product or process innovation. To test this hypothesis empirically, we first create a dummy variable that captures whether there is a decline in the number of firms in a given period based on Table 4 that shows these changes in percentage. For example, for the 2004 survey covering the years 2001-2003, we consider the number of active firms at the beginning of 2001 and at the end of 2003. If the growth rate is negative, the sector is considered to experience a "downturn" otherwise it is considered an "upturn." Next, we create "*industry downturn dummy*" variable. It is equal to 1 when both industrial production and number of firms declined in a given period and for a given industry. Model 4 to Model 6 in Table 6 show the effect of this new independent variable on the firm's propensity to engage in overall innovative activities, product innovation and process innovation. These models demonstrate that in such downturns firms tend to develop product innovations and produce fewer process innovations. In economic terms, the probability to engage in product innovation and process innovation in downturns increases by 11% and decreases by 12% respectively. This seems to suggest that when both the number of firms and industrial production decline in a given period/industry their combined effect on firms' innovative activities is stronger. Overall, these results confirm the findings in Tables 5.

As an additional robustness check, we also used a specification including the type of industry – in relative terms, *low-tech, medium-low-tech, medium-high-tech,* and *high-tech* industries – rather than 2-digit industry dummies as illustrated in Table 4. These are four different dummy variables, each capturing industry technological effort according to the OECD technology industry classification (Hatzichronoglou, 1997). As previous research suggests (e.g. Cainelli, De Liso, Monducci, & Perani, 2001; Mohnen & Dagenais, 2002; Nascia & Perani, 2002), industry type could strongly influence firms' innovative activities. The default case relative to the other three is "low-tech." Table 7 shows that firms in Low-tech industries are less likely to engage in innovative activities during downturns. Overall, our results are confirmed.

***** Please insert Table 7 about here *****

Fourth, we run our models including only those firms that are present in every wave. Although the number of observations declines to 1,653 (and 551 firms), we find similar findings. As a final test, we slightly change our dependent variables to accommodate those firms that engaged in more than one type of innovation. We created two new variables: broad product innovation and broad process innovation. The former is equal to 1 for firms that performed product innovation only or product and process innovation. The latter equals 1 if the firm engaged in process innovation only or in process and product innovation. Again, the results are similar to our prior findings (available from the authors).

Discussion & Conclusion

We examine the role of an important aspect of the economic environment on firms' innovation processes. By distinguishing product from process innovation we see that industry fluctuations have differential associations with each of these two types. In the case of industry downturns, firms tend to engage in product innovation rather than in process innovation. Our results have implications for both theory and research design.

From a theoretical perspective, our findings provide a contribution by bridging opportunity cost theory with the cash flow effect. The results clearly indicate how firms allocate their resources for innovative activities in an industry downturn — they realise new products rather new processes. Why? An explanation is likely to be derived by integrating these two previously incompatible arguments (see Figure 1).

***** Please insert Figure 1 about here *****

During an industry downturn, the revenues of current products may drop along with the value of existing products. Given that, firms may need to strategically re-allocate their limited resources. They may decide to restructure their relatively less profitable product activities by re-allocating resources to develop new innovative and potentially profitable products. The alternative option — engaging in process innovation — is less likely as it may not be profitable in the long term to increase the efficiency of producing existing products whose value may be plummeting. Therefore, firms seem to have incentives to engage *only* in product innovation as the loss of diminishing rents from current products is larger than the relative return to be secured by implementing new products (Arrow, 1962; Geroski, 1995; Saint-Paul, 1997). As a consequence, they may invest fewer resources in process innovation for depreciating products because the window of improving productivity for those products is rather small. On the contrary, by realizing new products, firms prepare themselves for the next upturn, which could provide the market with potential rent-generating product innovations. Overall, we contribute to the literature on the effect of downturns on a firm's propensity to innovative by clearly showing how some innovation activities may be counter-cyclical and others pro-cyclical. And the time horizon over which firms are able to profit from these activities is likely to influence the division between the two. During industry downturns, by engaging in product innovations, firms will benefit in the longer-term when the next expansion takes place. On the other hand, engaging in process innovation is likely to be a pro-cyclical activity as firms will benefit from such innovations in the shorter-term by improving existing products in times of high demand.

At first glance, it appears that our results are inconsistent with Nickell et al.'s (2001) work, where UK manufacturing firms seem to invest in managerial innovations oriented toward productivity improvement during negative business cycles. However, the way Nickell and co-authors measured this construct makes it difficult to compare directly with what we have studied. Nickell et al. focused on human resource practices, changes in industrial relations, and a perceived change in how "lean" the company became (which may or may not reflect lean manufacturing practices). Theoretically, all of these practices could be pursued simultaneously with product innovations.

From a research design point of view, separating product and process innovation adds insight over lumping them together in an all-encompassing innovation measure. As mentioned in the introduction, previous empirical studies have shown conflicting results regarding the influence of industry fluctuations cycles on firms' innovative activities. Despite the different empirical methods and samples employed, our results may provide us with an explanation for these previously conflicting results. When we combine product and process innovation together under the denomination of innovative activities, the effects of the determinants of interest are not significant. On the other hand, when we make a clear distinction between product and process innovation, we find that downturns are positively associated with product innovation and negatively with process innovation. Overall, these findings suggest that without a clear separation between product and process innovations, the effects of environmental factors could lead to blurred or biased results. When product and process innovations are concealed to the eye of the researcher, the relative weight of one type of innovation over the other one will define the significance and the direction of the relationship. For example, in a particular sample or industry when firms pursue relatively more process or product innovations, but a proxy that combined the two types is used, the results of any analysis will reflect the relatively higher weight of one type vis-à-vis the other. For example, by investigating how recessions influence a firm's R&D expenditure, Saint Paul (1993) find that such an effect is "sometimes positive, sometimes negative, and always very insignificant" (p.880). Such conflicting findings could be due to the fact that R&D expenditure often encompasses investments in both productivity-enhancing activities for existing products and the development of new products. By separating them, we argue, the results may have a different flavour.

The empirical separation of innovative activities into product and process innovation suggests that other factors could have an influence on firms' propensity to engage in innovative activities. For example, in Table 7 we find a negative relationship between product innovation and market concentration. This result is consistent with prior scholars that predict investments in product innovation to survive under competitive pressure (Porter, 1980, 1986; Weiss, 2003). Competition may increase innovation because firms have incentives to increase their technological lead over rivals in a 'neck-and-neck' technology race (Aghion, Howitt, Brant-Collett, & García-Peñalosa, 1998). Future research may explore different types of industries and how they react differently to industry fluctuations.

We point out the findings from this study are by no means definitive. Further investigations are required before broad prescriptions related to these findings can be made. First, the industry sector classification based on two-digit level may be not optimal to cluster firms. A more detailed level of analysis may provide a better aggregate measure and lead to more conservative results. Second, the variables built on the SIMF data may suffer from the typical 'subjectivity' weakness of any survey, such as reporting and fulfillment biases. Third, the measures employed for the dependent variables are not very nuanced. In addition, unlike CIS surveys, SIMF does not include questions on the novelty of product and process innovation. Distinguishing along this dimension may provide us a better sense of a firm's innovative behaviour. Fourth, the sample is a very comprehensive one, covering all areas of manufacturing activity in Italy. Inasmuch as Italian market structure may be idiosyncratic (e.g., a larger number of smaller firms than other OECD countries), the results may be less generalisable, although it is one of the largest economies in the world and one of the most developed, it is not obvious how a bias toward small firms should influence the results. If anything, one would expect less process innovation from smaller firms, which would make the results reported here more conservative. In addition, findings from this paper break new ground by providing large-sample empirical evidence on the environmental and market structure determinants of product and process innovation. Finally, our explanation for the underlying logic of realising product vs. process innovation was based on "matching" the patterns observed with the theories developed at the beginning of this article. This matching might well be modified as we learn more about these investments in future research.

Taken together, the findings provide some explanation for conflicting results of previous research where there was no distinction made between product and product innovation. By comparing two different perspectives, our results also provide an overarching theoretical explanation of firms' propensity to innovate in industry downturns. Finally, using finer-grained measures enables us to contribute to the important debate on the role of the economic environment on the innovation processes of firms.

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Table 1. Effects of industry downturns on a firm's propensity to innovate

During a downturn	Product innovation	Process innovation
Countercyclical argument **Reasons to pursue**	- Lower opportunity costs due to lower returns from existing products - Search for new market where demand might be growing - Risk reduction through diversification - Preemption on new products	- Lower opportunity costs as result of intertemporal substitution between process innovations and current productive activities - Productivity-improving activities provide firms with cost advantage when the demand recovers - Cost-saving process innovations could allow firms to reap profits despite the lower demand
Pro-cyclical argument **Reasons not to pursue**	- Due to cash flow constraints, firms are less prone to develop new products - Larger risk of failure due to uncertainty on the duration of the downturn and lack of confidence on consumer demand	- Fewer incentives for productivity-enhancing activities for products whose value is depreciated - Investment could be lost if current products do not meet future demand - Low return on investment due to lower demand

Table 2 -- *The Herfindhal-Hirschmann Index for manufacturing industries in Italy (year 2003) present in the panel data. The number of firms, the average firm's size and the propensity to engage in innovation in each industry is also displayed (for the entire panel)*

Division	Industry	Herfindhal Hirschmann Index	Number of firms in the panel	Number of firms in the panel (%)	Ave size	Firms engaged in innovation	Product innovation	Process innovation	Both product & process innovation
15	Food Prod. And Bev.	0.49%	46	7%	43	54.4%	6.7%	33.5%	14.2%
17	Textiles	0.49%	63	10%	134	55.9%	14.2%	24.7%	17.0%
18	Wearing Apparel, etc.	0.99%	19	3%	122	64.2%	17.8%	21.4%	25.0%
19	Tanning and Dressing of Leather; Luggage, etc.	0.32%	22	4%	53	58.3%	10.7%	33.8%	13.8%
20	Wood; Products of Wood, etc.	0.39%	36	6%	56	54.6%	8.6%	27.8%	18.2%
21	Paper and Paper Products	1.85%	22	4%	50	58.8%	11.4%	34.4%	13.0%
22	Publishing, Printing, etc.	1.75%	16	3%	92	68.7%	4.4%	35.5%	28.8%
24	Chemicals and Chemical Products	0.63%	22	4%	86	54.6%	12.5%	17.1%	25.0%
25	Rubber and Plastic Products	0.83%	42	7%	112	68.1%	6.3%	22.2%	39.6%
26	Other Non-Metallic Mineral Products	2.37%	40	6%	174	54.7%	13.9%	26.1%	14.7%
27	Basic Metals	2.33%	21	3%	180	56.3%	9.6%	25.8%	20.9%
28	Fabricated Metal Products, Except Machinery and Equipment	0.15%	61	10%	59	64.1%	8.5%	30.1%	25.5%
29	Machinery and Equipment	0.46%	128	21%	159	75.7%	24.3%	23.0%	28.4%
31	Electrical Machinery and Apparatus	1.46%	25	4%	121	81.8%	12.5%	16.6%	52.7%
32	Radio, Television and Communication Equipment, etc.	3.01%	10	2%	244	57.5%	19.2%	15.3%	23.0%
33	Medical, Precision and Optical Instruments, etc.	4.04%	12	2%	428	83.5%	18.7%	21.8%	43.0%
34	Motor Vehicles, Trailers and Semi Trailers	17.89%	10	2%	329	78.2%	3.5%	21.4%	53.3%
35	Other Transport Equipment	2.88%	4	1%	139	69.1%	30.7%	23.1%	15.3%
36	Furniture; Manufacturing	0.32%	23	4%	98	44.6%	9.2%	18.5%	16.9%
Total			622	100%	141	63%	13%	25%	26%

Source: The HHI is based on the AIDA database.

Table 3 – *Definitions and Statistics of the Variables Used to Identify the Determinants of innovative activities, 1995-2003*

Name	Definition	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Innovation	Dummy variable =1 if the firm performs innovative activities	0.64	0.48	0	1	1													
Product Innovation	Dummy variable =1 if the firm performs product innovation	0.14	0.34	0	1	0.30	1												
Process Innovation	Dummy variable =1 if the firm performs process innovation	0.25	0.44	0	1	0.44	-0.23	1											
Age	Log of the age of the firm since establishment	3.14	0.63	0.69	4.93	-0.01	0.04	-0.06	1										
Size	Log of the number of employees	3.91	1.08	2.48	8.56	0.22	0.06	-0.07	0.18	1									
R&D	Dummy variable =1 if the firm performs R&D activities	0.42	0.49	0.00	1.00	0.32	0.15	-0.08	0.06	0.35	1								
Industrial production downturn	The inversed of industrial production growth by industry sector	0.96	0.08	0.76	1.27	-0.08	0.09	-0.14	0.12	-0.01	-0.01	1							
Industrial production downturn dummy	Dummy Variable =1 if the industry experience a negative industrial production growth	0.32	0.47	0.00	1.00	-0.05	0.13	-0.17	0.10	0.04	0.08	0.7093	1						
Industry downturn	Dummy Variable = 1 if the industry sector experienced a negative growth in the industrial production and in the number of firms	0.22	0.41	0	1	0.02	0.17	-0.16	0.08	0.04	0.11	0.56	0.766	1					
China import	China import growth by industry sector	1.87	0.88	0	6.95	0.07	-0.01	0.05	-0.04	0.07	0.03	-0.42	-0.25	0	1.00				
HHI	Herfindhal-Hirschmann Index, continuous variable	0.01	0.02	0.002	0.18	0.06	-0.03	0.01	0.01	0.12	0.04	0.01	-0.02	-0.07	0	1			
South	Dummy Variable = 1 if firm is located in the South, else = 0	0.09	0.28	0.00	1	-0.04	-0.05	0.02	-0.13	-0.07	-0.11	0.04	-0.01	0.00	-0.03	-0.04	1		
Wave 1998-2000	Dummy Variable = 1 if firm is in a Low-Technology industry, else =0	0.33	0.47	0	1	-0.13	-0.03	-0.08	0.01	0.02	0.02	-0.09	-0.19	-0.37	0.03	0.00	0.01	1	
Wave 2000-2003	Dummy Variable = 1 if firm is in a Low-Mid-Technology industry, else = 0	0.33	0.47	0	1	-0.04	0.13	-0.17	0.17	-0.01	0.08	0.53	0.58	0.63	-0.23	0.00	-0.03	-0.49	1

Table 4 Illustration of the industrial Production growth rate, growth rate of the number of firms and the OECD Technology Industry Classification per industry sector and time wave.

Division	Description Industry	Industrial Production Growth rate	Growth rate in number of firms	Industrial Production Growth rate	Growth rate in number of firms	Industrial Production Growth rate	Growth rate in number of firms	OECD Technology Industry Classification
		1995-1997		1998-2000		2001-2003		
15	Food Prod. And Bev.	0.8%	1.5%	11.4%	20.4%	4.6%	6.5%	Low-Technology
17	Textiles	3.5%	-6.5%	-3.6%	14.7%	-7.0%	-8.0%	Low-Technology
18	Wearing Apparel, etc.	10.1%	-5.2%	0.8%	18.7%	-7.3%	-2.2%	Low-Technology
19	Tanning and Dressing of Leather; Luggage, etc.	12.4%	-5.0%	-12.1%	19.6%	-10.3%	-3.6%	Low-Technology
20	Wood; Products of Wood, etc.	-1.5%	-2.7%	15.4%	4.7%	3.7%	-3.2%	Low-Technology
21	Paper and Paper Products	5.1%	-1.4%	11.4%	28.0%	4.5%	-1.2%	Low-Technology
22	Publishing, Printing, etc.	0.9%	3.6%	10.2%	34.0%	0.4%	1.2%	Low-Technology
24	Chemicals and Chemical Products	-1.5%	-1.7%	3.6%	40.4%	-0.6%	-3.0%	Medium-Low-Technology
25	Rubber and Plastic Products	8.7%	-2.2%	4.9%	26.5%	1.7%	-0.4%	Medium-Low-Technology
26	Other Non-Metallic Mineral Products	8.2%	-0.8%	10.2%	21.2%	-2.8%	0.5%	Medium-Low-Technology
27	Basic Metals	3.5%	3.8%	10.9%	26.1%	1.5%	-5.7%	Medium-Low-Technology
28	Fabricated Metal Products, Except Machinery and Equipment	11.7%	-0.8%	-1.0%	14.6%	-4.3%	2.3%	Medium-Low-Technology
29	Machinery and Equipment N.E.C.	5.4%	0.7%	7.2%	18.9%	-0.7%	0.0%	Medium-High-Technology
31	Electrical Machinery and Apparatus N.E.C.	31.6%	-1.1%	5.8%	19.2%	-2.1%	-1.3%	High-Technology
32	Radio, Television and Communication Equipment, etc.	10.3%	-1.3%	3.6%	14.7%	-7.2%	-6.3%	High-Technology
33	Medical, Precision and Optical Instruments, etc.	-16.5%	0.6%	-25.0%	9.6%	-7.3%	0.3%	High-Technology
34	Motor Vehicles, Trailers and Semi Trailers	18.2%	0.9%	5.5%	44.2%	-7.8%	4.8%	Medium-High-Technology
35	Other Transport Equipment	10.4%	0.9%	5.5%	35.1%	-9.4%	9.7%	Medium-High-Technology
36	Furniture; Manufacturing N.E.C.	9.7%	-0.4%	12.2%	15.5%	-0.4%	0.0%	Low-Technology

Source: ISTAT for the industrial production growth and "Movimprese" a database managed by Infocamere, The Association of the Italian Chambers of Commerce for the number of firms

Table 5 – *Panel probit models*

	Panel Probit with Random effects		
	Model 1 Innovation	Model 2 Product Innovation	Model 3 Process Innovation
R&D	0.833***	0.353***	-0.0316
	(0.078)	(0.095)	(0.076)
Age	-0.0491	0.0239	0.0168
	(0.057)	(0.075)	(0.054)
Size	0.224***	0.0274	-0.0621*
	(0.039)	(0.044)	(0.035)
China import	-0.0464	0.154**	-0.0497
	(0.050)	(0.077)	(0.049)
HHI	2.460	-2.754	1.367
	(2.10)	(3.33)	(1.89)
South	-0.0393	-0.221	0.0420
	(0.12)	(0.18)	(0.12)
Industrial production downturn	-0.165	2.236***	-1.262**
	(0.64)	(0.80)	(0.63)
Wave 1998-2000	-0.733***	0.0904	-0.550***
	(0.087)	(0.12)	(0.083)
Wave 2000-2003	-0.568***	0.311**	-0.699***
	(0.11)	(0.14)	(0.11)
Textiles	-0.279*	0.185	-0.184
	(0.17)	(0.24)	(0.16)
Wearing Apparel	0.117	0.389	-0.217
	(0.22)	(0.31)	(0.23)
Tanning and Dressing of Leather; Luggage, etc.	0.0761	-0.0247	0.120
	(0.22)	(0.33)	(0.21)
Wood; Products of Wood, etc.	0.0113	0.210	-0.0993
	(0.18)	(0.27)	(0.17)
Paper and Paper Products	0.153	0.340	0.140
	(0.21)	(0.31)	(0.21)
Publishing, Printing, etc.	0.382	-0.570	0.0891
	(0.25)	(0.46)	(0.24)
Chemicals and Chemical Products	0.228	0.375	-0.401*
	(0.22)	(0.29)	(0.22)
Rubber and Plastic Products	0.0986	-0.243	-0.321*
	(0.17)	(0.28)	(0.17)
Other Non-Metallic Mineral Products	-0.213	0.340	-0.214
	(0.18)	(0.26)	(0.17)
Basic Metals	-0.0629	-0.184	-0.0938
	(0.23)	(0.35)	(0.23)
Fabricated Metal Products, Except Machinery and Equipment	0.288*	0.171	-0.0432
	(0.16)	(0.24)	(0.16)
Machinery and Equipment N.E.C.	0.105	0.596***	-0.363**
	(0.15)	(0.22)	(0.15)
Electrical Machinery and Apparatus N.E.C.	0.618**	0.123	-0.496**

	(0.25)	(0.30)	(0.23)
Radio, Television and Communication Equipment, etc.	-0.134	-0.309	-0.350
	(0.38)	(0.52)	(0.40)
Medical, Precision and Optical Instruments, etc.	0.438	0.493	-0.263
	(0.32)	(0.37)	(0.28)
Motor Vehicles, Trailers and Semi Trailers	0.149	-5.961	-0.156
	(0.36)	(9078)	(0.35)
Other Transport Equipment	0.225	1.111***	-0.467
	(0.38)	(0.43)	(0.40)
Furniture; Manufacturing N.E.C.	-0.623***	0.0432	-0.550**
	(0.21)	(0.31)	(0.22)
Constant	-0.0278	-4.337***	1.398**
	(0.65)	(0.84)	(0.64)
Observations	1795	1795	1795
Number of Firms	622	622	622
Chi Squared	270.6	94.70	141.9

Table 6. The relationship between industry downturn (dummy) and product/process innovation.

	Panel Probit with Random effects					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Innovation	Product Innovation	Process Innovation	Innovation	Product Innovation	Process Innovation
R&D	0.833***	0.356***	-0.0322	0.832***	0.354***	-0.0249
	(0.078)	(0.095)	(0.076)	(0.078)	(0.096)	(0.076)
Age	-0.0493	0.0268	0.0146	-0.0478	0.0260	0.0139
	(0.057)	(0.075)	(0.054)	(0.057)	(0.076)	(0.054)
Size	0.224***	0.0244	-0.0617*	0.224***	0.0261	-0.0634*
	(0.039)	(0.044)	(0.035)	(0.039)	(0.044)	(0.035)
China import	-0.0450	0.105	-0.0336	-0.0419	0.0875	-0.0201
	(0.048)	(0.074)	(0.047)	(0.048)	(0.073)	(0.046)
HHI	2.426	-2.014	1.212	2.601	-0.761	0.711
	(2.09)	(3.23)	(1.88)	(2.09)	(3.22)	(1.87)
South	-0.0394	-0.213	0.0370	-0.0443	-0.231	0.0450
	(0.12)	(0.18)	(0.12)	(0.12)	(0.19)	(0.12)
Industrial production downturn dummy	-0.0407	0.285**	-0.255**			
	(0.10)	(0.14)	(0.11)			
Industry downturn dummy				0.146	0.537***	-0.406***
				(0.11)	(0.14)	(0.12)
Wave 1998-2000	-0.733***	0.171	-0.563***	-0.725***	0.238**	-0.620***
	(0.086)	(0.11)	(0.081)	(0.086)	(0.11)	(0.080)
Wave 2000-2003	-0.560***	0.379***	-0.676***	-0.653***	0.253*	-0.639***
	(0.11)	(0.14)	(0.11)	(0.11)	(0.14)	(0.10)
Constant	-0.188	-2.195***	0.178	-0.169	-2.155***	0.172
	(0.25)	(0.35)	(0.23)	(0.25)	(0.35)	(0.23)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1795	1795	1795	1795	1795	1795
Number of Firms	622	622	622	622	622	622
Chi Squared	342.0	117.6	151.5	343.5	127.4	157.2

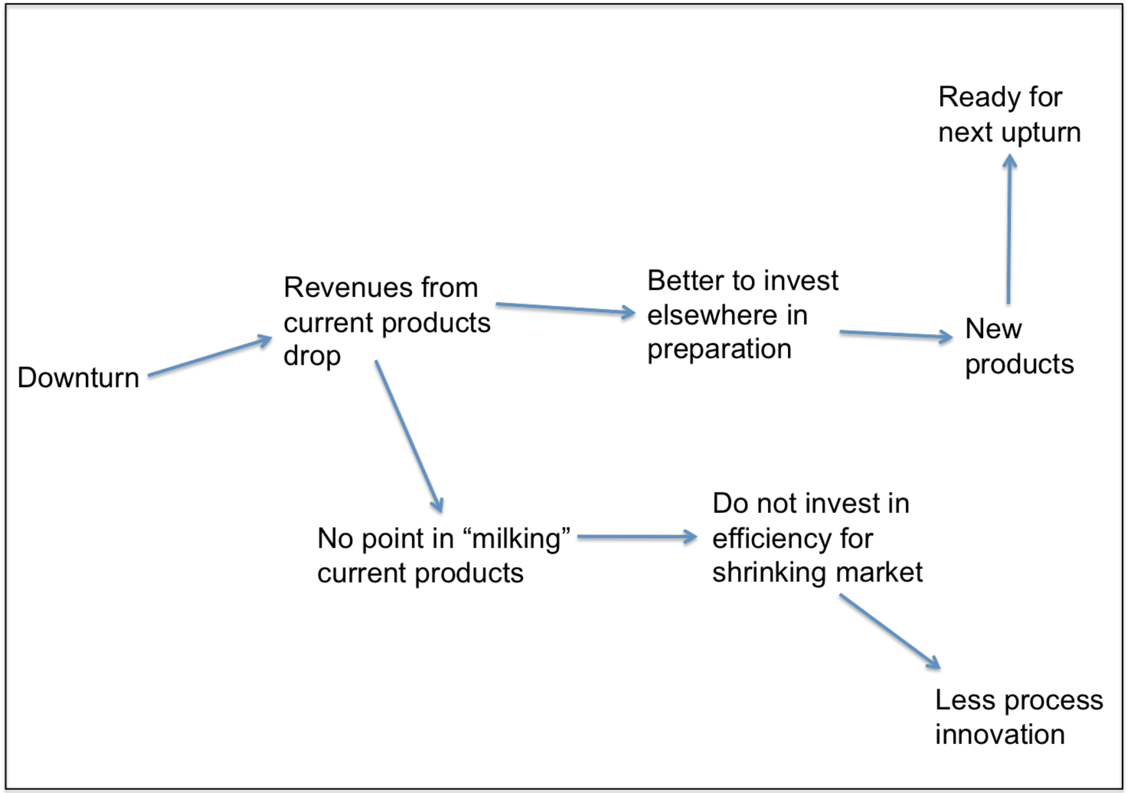
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7. Panel Probit models with industry type classification.

	Panel Probit with Random effects								
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
	Innovation	Product Innovation	Process Innovation	Innovation	Product Innovation	Process Innovation	Innovation	Product Innovation	Process Innovation
R&D	0.839***	0.368***	-0.0621	0.841***	0.362***	-0.0532	0.838***	0.353***	-0.0412
	(0.078)	(0.094)	(0.074)	(0.078)	(0.093)	(0.074)	(0.078)	(0.094)	(0.075)
Age	-0.0463	0.0346	0.0155	-0.0483	0.0419	0.00970	-0.0458	0.0471	0.00704
	(0.058)	(0.075)	(0.053)	(0.058)	(0.074)	(0.053)	(0.058)	(0.075)	(0.053)
Size	0.205***	0.0164	-0.0733**	0.207***	0.0127	-0.0702**	0.203***	0.0118	-0.0720**
	(0.039)	(0.043)	(0.034)	(0.039)	(0.043)	(0.034)	(0.039)	(0.043)	(0.034)
China import	-0.0142	0.0775	-0.0196	-0.00995	0.0431	-0.00597	-0.00342	0.0298	0.00323
	(0.044)	(0.060)	(0.042)	(0.042)	(0.059)	(0.040)	(0.042)	(0.059)	(0.040)
HHI	2.301	-6.212**	2.093	2.090	-5.136**	1.698	2.193	-4.067	1.055
	(1.83)	(2.64)	(1.54)	(1.80)	(2.51)	(1.53)	(1.82)	(2.51)	(1.54)
South	-0.0452	-0.233	0.0417	-0.0490	-0.218	0.0313	-0.0515	-0.241	0.0468
	(0.12)	(0.18)	(0.12)	(0.12)	(0.18)	(0.12)	(0.12)	(0.18)	(0.12)
Industrial production downturn	-0.470	1.828***	-1.013*						
	(0.55)	(0.69)	(0.53)						
Industrial production downturn dummy				-0.113	0.267**	-0.244***			
				(0.088)	(0.11)	(0.091)			
Industry downturn dummy							0.0394	0.471***	-0.430***
							(0.10)	(0.13)	(0.11)
Wave 1998-2000	-0.716***	0.0949	-0.546***	-0.717***	0.154	-0.553***	-0.726***	0.216**	-0.611***
	(0.086)	(0.11)	(0.081)	(0.086)	(0.11)	(0.080)	(0.085)	(0.11)	(0.080)
Wave 2000-2003	-0.516***	0.325**	-0.691***	-0.494***	0.355***	-0.650***	-0.579***	0.256*	-0.595***
	(0.10)	(0.13)	(0.100)	(0.10)	(0.13)	(0.100)	(0.10)	(0.13)	(0.099)
Medium-Low-Technology	0.219**	-0.0473	-0.103	0.225**	-0.0698	-0.0985	0.226**	-0.0306	-0.123
	(0.091)	(0.13)	(0.088)	(0.091)	(0.12)	(0.088)	(0.092)	(0.13)	(0.088)
Medium-High-Technology	0.0809	0.445***	-0.227**	0.0947	0.378***	-0.188**	0.0989	0.360***	-0.173**
	(0.093)	(0.12)	(0.093)	(0.090)	(0.11)	(0.088)	(0.090)	(0.11)	(0.088)
High-Technology	0.512***	0.128	-0.317**	0.517***	0.128	-0.300**	0.492***	0.0710	-0.261*
	(0.17)	(0.19)	(0.15)	(0.17)	(0.19)	(0.15)	(0.17)	(0.19)	(0.15)
Constant	0.189	-3.685***	1.063*	-0.247	-1.970***	0.125	-0.265	-1.978***	0.133
	(0.58)	(0.74)	(0.55)	(0.22)	(0.30)	(0.21)	(0.22)	(0.30)	(0.21)
Observations	1795	1795	1795	1795	1795	1795	1795	1795	1795
Number of Firms	622	622	622	622	622	622	622	622	622
Chi2	248.7	82.57	126.7	249.7	81.52	129.6	307.5	100.6	143.4

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Figure 1



Downturn
Revenues from current products drop
Better to invest elsewhere in preparation
New products
Ready for next upturn
No point in “milking” current products
Do not invest in efficiency for shrinking market
Less process innovation