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INNOVATION STRATEGIES AND CONSUMPTION TRENDS IN ITALY: A FOCUS ON THE AGRO-FOOD SECTOR

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Innovation strategies and consumption trends in Italy: a focus on the agro-food sector

Abstract

Two main factors explain the existing competitive pressure on food and agriculture system: changes in food consumption habits and the increasing role of large retailers within the food market chain. Changes in food habits are complex and characterized by two primary trends: relative decline of household food expenditure and increasing in out-of-home food consumption. In Italy, changes in lifestyle depend on a number of demographic factors, two of which mainly emphasized in this paper: ageing and immigration. Beside these factors, many other reasons induce food enterprises to invest in new technologies to meet the increasing demand of snacks and precooked food products, the larger number of people eating in restaurants or fast-foods, and the diffusion of variegated and diversified diets. Has the Italian research and innovation system the capacity to meet such challenges driven by new consumption trends and markets' globalization? This study tries to answer this question, through those main indicators economists adopt to measure the innovation capacity (total factor productivity, investment research intensity in agricultural and food production, businesses expenditure for innovation activities and patent applications). These indicators are analysed having in mind two main characters of the Italian agro-food system: predominance of small and medium sized enterprises and their propensity - even under new consumers trends - to prevalently compete on prices. If contribution of agro-food sector to national economic growth is expected to improve, a "follower" research and innovation system does not seem able to provide the needed improvements, in terms of either price-driven competition or higher value-added differentiation strategies. This contribution seems "potentially" relevant particularly for the less developed areas of the country.

Strategie di innovazione e trend dei consumi in Italia: il caso dell'agro-alimentare

Sommario

La pressione competitiva sul sistema agro-alimentare del Paese deriva da due fattori principali: le evoluzioni delle abitudini alimentari dei consumatori e l'affermarsi della Grande Distribuzione Organizzata. I cambiamenti delle abitudini alimentari sono complessi e caratterizzati da due *trend* principali: la diminuzione della spesa della famiglia dedicata al paniere alimentare e l'aumento dei consumi fuori casa. Anche importanti fenomeni demografici sono collegabili alle modifiche nello stile di vita italiano: l'invecchiamento della popolazione e l'aumento dell'immigrazione sono due dei fattori considerati in questo studio. Cibi precotti, maggiore frequentazione di ristoranti, consumo di *snack*, diversificazione e varietà della dieta alimentare impongono nuove sfide tecnologiche alle aziende alimentari. Ma qual è la capacità del sistema di ricerca e di innovazione in Italia di cogliere queste sfide collegate ai *trend* di consumo e alla globalizzazione dei mercati? Questa ricerca prova a rispondere a questa domanda chiave, interpretando alcuni degli indicatori più utilizzati dagli economisti per misurare le capacità innovative di un settore economico (andamenti della produttività totale dei fattori, intensità di spesa in ricerca per l'agricoltura, spesa delle aziende per l'innovazione e capacità brevettali). Questi dati vengono letti alla luce di due caratteristiche centrali dell'agro-alimentare italiano: la prevalenza di aziende di piccole e medie dimensioni e il peso, nonostante le evoluzioni delle attitudini dei consumatori, del fattore prezzo nella competitività del prodotto. Sia che si continui a competere sul prezzo, sia che ci si sposti su strategie di differenziazione e di qualità, un sistema di ricerca "adattivo passivo" non sembra possa garantire il salto necessario affinché questo settore possa migliorare il suo contributo alla crescita economica. Contributo "potenzialmente" rilevante proprio per le aree più disagiate del Paese.

This paper was prepared by Roberto Esposti, Sabrina Lucatelli and Elena Angela Peta. It is the product of a project on research and innovation in the agro-food sector coordinated by Sabrina Lucatelli as part of initiatives to support the development of rural areas of the Public Investment Evaluation Unit.

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I. Introduction

The Italian agro-food system is increasingly shedding its old configuration as an undifferentiated sector, a producer of low value-added raw materials, to become a producer of higher value-added products. Agriculture is a sector that forms part of broader integrated systems - whether production systems such as the agro-food industry, or territorial systems, of which it may be one of the key assets (for example, agriculture within a park area) - that is moving increasingly towards offering "services" in addition to products and raw materials. Whether the final product is a food product or leveraging territorial resources, agriculture is part of a broader economic system where competition does not focus solely on the price of the agricultural good, but also on the ability to differentiate it from the rest. This dynamic is being driven by changes in the market and in consumer preferences.

For agriculture to contribute to the competitiveness of the economic systems to which it belongs - territorial (park areas, landscape enhancement) or productive (food and energy) - research and innovation strategies play a crucial role. Meeting stringent quality standards and guaranteeing food safety, for example, call for an essential degree of modernisation of the sector; the use of input with increasingly precise characteristics; compliance with ever-more sophisticated environmental standards and the adoption of traceability systems. These are all fields in which researchers can and must achieve the necessary advances.

This study seeks to assess the needs and opportunities for research and innovation in the Italian agro-food field, starting with an analysis of the factors that have driven and will continue to drive major changes in the eating habits of Italian households: changing life-styles, the trend towards single nucleus households and/or smaller families, the greater (if still unsatisfactory) participation of women in the workforce, the lengthening of children's school careers and the aging of the population have all contributed to increased consumption outside of the home, to the flourishing of catering and school cafeterias and to major changes in the population's diet. Significant pressures on agricultural and food companies to upgrade production process and technology have also been exerted by the expanding role of large retailers in Italy, although this development has differed by depending on the area. These consumption dynamics have spurred new "demand" for advanced technologies.

Starting with the analysis of the new demand for advanced technologies, the study attempts to gauge the Italian agro-food system's propensity to innovate, analysing both public investment in agro-food research and the propensity of Italian agro-food firms to adopt innovation strategies. Where statistics are available, Italy and other European Union countries, or major global agro-food economies, are compared.

From a development standpoint, it is important to note that the agro-food industry accounts for 7.4 per cent of total Italian exports, of which no less than 5.8 per cent consists of processed foods. This figure has risen over the last decade, thanks largely to the contribution of higher value-added exports.[1] Moreover, the supply of quality agricultural products and the role that agriculture plays in landscape use are crucial for local development. It follows that the role of research and innovation in boosting the competitiveness of the agro-food system can have a significant impact on local territories, and therefore on the growth of the country from the viewpoint of cohesion, which depends upon the degree of integration of the systems (and the degree of their attachment to the territory), upon the quality and impact of research activity focusing on a given territory, and on the existence of networks of actors who know how to disseminate and make use of the results.

The creation of a system of services that meets the research needs of the agro-food system, and the ability of agricultural and food companies to adopt innovation strategies is particularly important considering how crucial the agro-food system is to certain regions of Southern Italy. In that area of the country, the agro-food industry employs 10.6 per cent of the population in employment (compared with 5.4 per cent in Central and Northern Italy); it contributes 7 per cent of the added-value of the area and, very importantly, agro-food exports from this area constitute just under 30 per cent of annual national agricultural exports and 15 per cent of food product exports.

However, the fact remains that investment in research and development and the adoption of innovation strategies are especially difficult in a country characterised by very small agricultural enterprises[2] and small and medium-sized food companies.[3] These size characteristics of the agro-food system can impact its propensity to innovate. Other variables may also play a role in this discouraging situation, such as the aging of those

[1] Higher valued-added exports refers to food products (processed). These increased at an average annual rate of 4.9 per cent between 1995 and 2003 compared with an average annual growth rate of 2.5 per cent for agricultural exports.
[2] In Italy, the average size of a farm in terms of utilised agricultural area is 5.5 hectares, compared with a Community average of 18.7 hectares (source: Eurostat 2000).
[3] In Italy, about 56 per cent of food product companies employ between 10 and 249 workers, making them SMEs.

engaged in agriculture and their low level of educational attainment. These are all factors that place the South in a particularly critical position.[4]

Improving the economic policy choices that play a part in shaping the national research and innovation system for the agro-food sector could have a significant impact on the competitiveness of many of the most backwards areas of the country, and, as a result, on Italy's growth processes. From the standpoint of market globalisation, in a sector where competitiveness is increasingly important given the slow but steady liberalisation (and a reduction in support) of the agricultural sector and the presence of multinational food groups and large retail chains, purely adaptive strategies, like those adopted up until now by Italy, could threaten the potential economic role of the agro-food system.

[4] In fact, average farm size in Southern Italy is 4.4 hectares, compared with 8.1 hectares in Central and Northern Italy. While the percentage of small and medium-sized firms (10-249 workers) in the food industry as a whole is 58.04 per cent, this percentage is 70.34 per cent in the South.

II. Food consumption in Italy and new technologies[5]

The proportion of total expenditure by Italian households spent on food has declined significantly over the last ten years. In 1992, 18.3 per cent of total household expenditure went towards food products, while 6.5 per cent went to meals consumed outside of the home. In 2005, these percentages were 14 per cent and 7.4 per cent, respectively.[6]

A comparison of the data on household consumption from the start of the 1990s with the figures for 2000 reveals a decline in the proportion of total household spending on food. However, there was a partial increase in spending on meals consumed outside of the home (Figure II.1).

A comparison of food expenditure patterns in the three areas of the country shows how this trend has been driven by diminishing expenditure in the North, whereas the decline in food expenditure in the South and the Islands was smaller, and in Central Italy spending has held constant (Annex A, Figure A.1). Consumption of meals outside of the home rose in all areas of the country. This trend has been driven by the South and the Islands, with an average annual increase of 2.5 per cent in such spending between 1997 and 2004 (Annex A, Figure A.2).

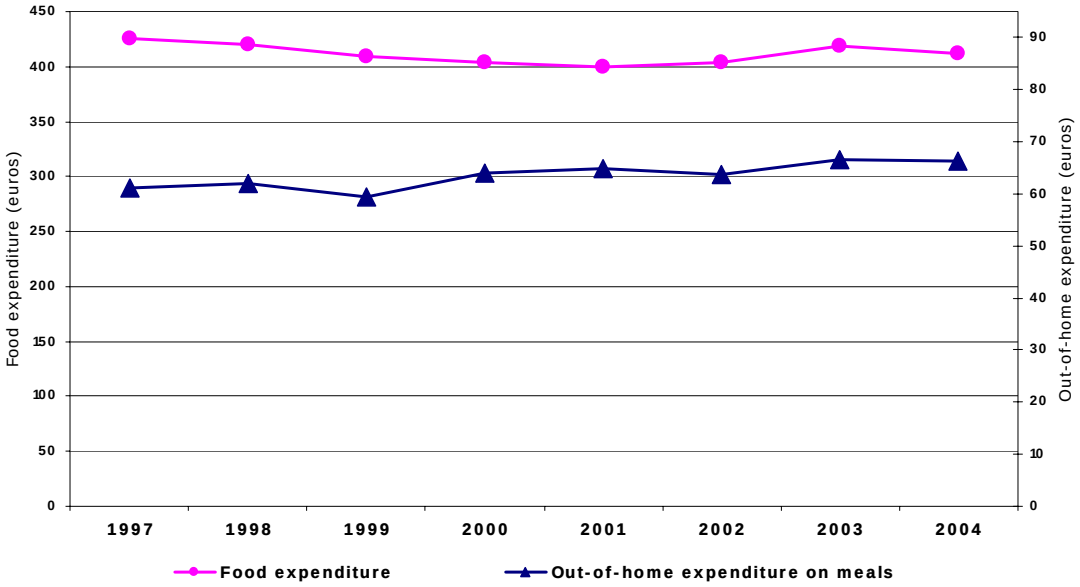
Taking into account these general trends, we can turn to identifying the socio-economic factors that underlie the changes in Italian household food consumption and will determine developments in the medium term. The aim is to identify the link between the main changes (general and territorial) in agro-food consumption in Italy and research and innovation needs. The key factors in the evolution of food consumption habits are:

- major socio-demographic and life-style changes;
- the emergence of more knowledgeable consumers and a greater focus on diet;
- income and purchasing power disparities among Italian households.

[5] For more information, see E. A. Peta, "Consumi agro-alimentari in Italia e nuove tecnologie", Programma Diffusione delle Conoscenze – Department for Development Policies – Ministry for Economic Development, Rome 2007.

[6] National Accounts, *Tomo 1 Conti economici nazionali anni 1992-2003, Annuario n. 9*, October 2006 update, ISTAT.

Figure II.1 Average monthly household expenditure in Italy: food products and meals consumed outside the home (1997-2004, current values)



Source: UVAL based on data from ISTAT "*Indagine sui consumi delle famiglie, 1997-2004*".

The primary socio-demographic trends in Italy prompting this shift in food expenditure habits are the aging of society, the movement towards single nucleus households and new lifestyles, and a growing multi-ethnic culture.

As to how the population structure is changing, statistical projections from the most recent demographic simulation performed by ISTAT through the year 2050 show that the population of those over 65 is expected to grow from 19.5 per cent of the population in 2005 to 33.6 per cent in 2050. Projections also show that the aging index[7] will double between 2005 and 2050, accelerating in particular after 2020.

In terms of food consumption, this dramatic aging of the population will have an impact on diet due to the health needs of an older population and preferences for safer and healthier foods. This suggests that actual or potential scientific discoveries in these areas, such as, for example, those involving novel foods, light products and health foods, will play a central role.

Another significant driver of this change is household composition. According to the ISTAT multi-purpose household study,[8] in 2003 households in Italy tended to be made

[7] The aging index is the ratio of persons aged 65 and over to those aged 0-14 (Pop65+/Pop0-14).

[8] "*Famiglie e soggetti sociali*". Since 1993 ISTAT has conducted an annual survey of aspects of households' daily lives. In 2003, ISTAT examined the evolution of the composition of Italian households in recent years. It defined a household as

up a single family nucleus (more than one-fourth of these made up of just one person)[9]. There are more single-person households in Northwest and Central Italy, where the population is older. In the South, by contrast, there are more households composed of at least one nuclear family (around 76 per cent). The number of large families has fallen overall, although this type of household persists in the South (roughly 11 per cent of all families are considered large, compared with 5 per cent in the rest of the country). Central-Northern Italy has a larger proportion of childless couples, unmarried couples living together, blended families and single-parent households.

These demographic trends have sparked a change in eating habits, since the large number of single-person households and the spread of a new family model has fostered more eating outside the home and the consumption of pre-cooked and single-serving meals. The advent of a new lifestyle, spurred by the very hectic times we live in, the entry of women into the labour force,[10] limited free time and the spread of shorter breaks have had a considerable impact on the traditional practice of eating at home. According to household consumption data compiled by ISTAT, average monthly expenditure on meals and food consumed outside the home over the last few years has been growing, rising from €61.22 in 1997 to €66.26 in 2004.[11] During this period, average monthly household spending on restaurant meals in the North was about €78 per month, compared with under €41 per month in the South.[12] Another interesting development in the rise in meal consumption in company and school cafeterias, as well as the use of beverage and snack vending machines in schools, the workplace and on university campuses. According to ISTAT,[13] the habit of consuming meals outside the

a group of persons linked by cohabitation, marriage or consanguinity, affinity, adoption, guardianship or emotional ties; a family nucleus is represented by persons who form a couple with unmarried children, a childless couple, or a single parent and his/her unmarried children. According to ISTAT a household can consist of a single family nucleus, a family nucleus and additional persons, by more than one family nucleas (with or without additional persons), or with no family nucleus (for example, households composed of two sisters, a parent with a separated or widowed child, etc).

[9] In 1995 in Italy, single-person households represented about 21 per cent of all Italian households, while in 1998 they made up 22 per cent. In 2003, this figure reached 26 per cent.

[10] This phenomenon varies greatly from region to region in Italy.

[11] The figures have been deflated on the basis of 2000 prices.

[12] According to the ISTAT household study *Aspetti della vita quotidiana*, observing trends in monthly spending on meals outside of the home in different areas of the country, the figures for Central-Northern Italy were above the national average in 2003, although the greatest growth occured in the Northwest of the country (9.2 per cent in 2003), while the South, though rising, is well below the national average (2.4 per cent in 2003).

[13] *Aspetti della vita quotidiana* for 2003.

home starts early in life, with 55 per cent of school-aged children between the ages of 3 and 5 eating lunch in school cafeterias.[14]

The increase in immigration must also be taken into account. In recent decades, Italy has gone from a country with a high rate of emigration to one of immigration.[15] According to demographic projections from ISTAT, this trend should continue. There has also been a structural change in the immigrant population due to the increase in applications for residence permits for family reunification. As a result, the number of young female immigrants has rising, which has contributed to the shift towards more diversified eating, with the introduction of "new" foods from the immigrants' home countries.[16] As we will see, this has increased the importance of new technologies in food preservation and packaging.

The second factor to consider is the emergence of a more knowledgeable consumer segment, one that places greater emphasis on food quality. This factor is linked to investment in human capital and education levels, but also, over the last twenty years, to a series of food-related scandals (methanol-adulterated wine, BSE or "mad cow" disease, and dioxin-contaminated chicken) that have focused consumer attention on the different forms of food information and labelling. Consumer demand for food guarantees and safety, along with substantial regulatory activity in recent years at the European and national levels and the establishment of quality standards (both public and private, particularly by large retail chains), explains the growing use of food traceability techniques. Traceability makes it possible to reconstruct all the major stages[17] through which a product from its origin to the final consumer.[18]

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[14] In recent years, organic products have become more widely available in school cafeterias. In fact, according to Biobank data from Coldiretti, the number of cafeterias that serve organic products has increased considerably over the last ten years, from 64 in 1996 to 647 in 2006.

[15] According to ISTAT's *Bilancio demografico nazionale*, immigrant's made up 4.5 per cent of the population in 2005.

[16] Particularly among younger generations, there has been an increase in consumption of foods that are not typically Italian, such as sushi, Argentine beef, oriental delicacies and other typical Mediterreanan dishes, such as kebabs, cous cous and Iberian ham (*Jamon Iberico*).

[17] The traceability of foods can be applied if concepts or techniques are developed to fine-tune "tracing molecules" to aid in the certification of origin of each nutritional component. (P. Manzelli, Research from the Education Research Laboratory (LRE), Chemistry Department of the University of Florence, *scuolanews* no. 3, May 2002).

[18] This can be direct ("from farm to fork") or indirect ("from fork to farm", or traceability). Traceability enables reconstruction of the entire food production and distribution chain, starting from consumption of the product through every stage of food handling and production to the primary production field. This makes it possible to identify the exact step at which any regulatory irregularities or fraud or food safety lapses may have occured (ibid).

This increased awareness of and attention to the characteristics of foods is also linked to the rise, since the 1980s, in the percentage of people affected by food-related pathologies. The most worrying are the rise in obesity and in allergies and intolerance of certain foods.[19]

Obesity is increasing sharply, even in Italy. The change in eating habits is among the major causes of the rapid spread of this pathology. Experts have noted that, in some areas of Europe, the rates of overweight people in the adult male population are approaching that reached by the United States in the late 1990s.[20] The situation with young people is of particular concern. Despite the lack of consistent official statistics at the European level, according to IOTF[21] parameters, more than one out of three children in Europe (about 36 per cent) have a weight problem. In Italy, the highest number of overweight children is found in the 7 to 11-year age range, which places Italy first in Europe, with the highest percentage for male children. In 2001, these percentages were around 27 per cent for males and 21 per cent for females (a much higher figure than those reported by France and Germany).

In the face of this development, national and international institutions are working together to identify policy solutions to this problem. These include primarily prevention-based policies, using improved information and dietary and nutritional education directed at certain professions, such as pediatricians and educators (as well as teachers and parents). This promotional campaign[22] could encourage consumers to opt for a varied diet both at home and in school cafeterias. Pathologies linked to obesity have also led to increased consumption of foods with therapeutic benefits, such as soy-based products[23] for the prevention of cardio-vascular diseases.

Other conditions that are strongly linked with diet are food allergies and intolerances, which have risen steeply over the last few decades. This has led to an increase in "designer" foods, i.e. foods with ideal nutritional characteristics compared with those not tolerated by the body of the individual affected by these conditions.

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19 According to the WHO, poor eating habits are also the leading cause of cancer.

20 Mazzocchi M., *Nutrizione, Salute e interventi di politica economica in Europa*, Agriregionieuropa no.1, June 2005.

21 International Obesity Taskforce, an international network of researchers who study obesity with a special focus on the rising level of the pathology among children.

22 The dissemination of the dietary education campaign encouraged adults in particular to pay greater attention to their eating habits, showing an active interest in the results of numerous scientific studies published in recent years that argue that a good diet is a varied diet, i.e. greater consumption of fruits, vegetables and legumes, moderate consumption of fish, little meat and greater focus on fresh products.

23 Soy contains isoflavons, which are vegetable-based phytoestrogens, similar in structure to the estrogens found in the human body.

The final factor to be considered is the disparity in income distribution, which is reflected in the purchasing power of Italian individuals and households. Italy has a high Gini index[24] score (in 2004, the index was 0.331), showing considerable inequalities in income distribution. The existence of sharp differences in the distribution of income and the difficulty of achieving higher average incomes – thereby avoiding the existing polarisation – means that the dietary behaviours that one would expect from higher-income consumers (who demand more services, are more careful about on health-related issues and food safety, and more willing to invest in differentiated and quality products) risks remaining a minority phenomenon.

The income disparities that exist in different areas of the country and the higher poverty rate in the South suggest that price continues to be an important factor in deciding whether to purchase a food product. This is all the truer the larger are the strata of the population in Italy considered low-income or near the poverty line.

In 2005, according to the household consumption survey, 2.6 million households in Italy were classified as poor, amounting to 11.1 per cent of total resident households, corresponding to 7.6 million persons (about 13.13 per cent of the total population).[25] An examination of this phenomenon in the various areas of the country shows that in Northern and Central Italy, the household poverty rate was around 4.5 per cent and 6 per cent, respectively, while in the South, the figure reached 24 per cent, with 70 per cent of poor Italian households concentrated in this area. The poverty rate has climbed slightly since the early 1980s (about 10 per cent), but has remained relatively stable over the last three years.

The income difference is one feature of the economic gap between the North and the South. Household income in the South is about three-quarters that in the North. At lower income levels, a larger portion of household income is spent on food products and eating habits differ. However, the elasticity of demand with respect to food prices varies based on the level of household income and the type of consumption involved.

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[24] The Gini index measures the concentration of the income distribution. It is a composite metric of income inequality. If there is a perfect distribution (all households have the same income), the coefficient is equal to 0. A coefficient of 1 corresponds to complete inequality (when total income is held by just one household). A comparison with the index figures for other countries shows that Italy is among the countries with the highest such scores (> 0.31) along with other Mediterreanean countries (Portugal, Spain and Greece) and some Eastern European countries (Poland, Romania, Estonia, Latvia and Lithuania).

[25] ISTAT calculates the poverty line based on the average monthly expenditure of households covered in the annual household consumption survey of a sample of 28,000 households, chosen at random, representing all resident Italian households. In 2005, the poverty line for a two-person household was €936.58 per month, €17 more than in 2004.

The elasticity of demand in relation to the price of preferred foods is also connected with the type of food. It is interesting to note that, according the ISTAT household consumption survey,[26] 15 per cent of households, under the pressure of inflation, chose to buy lower-quality products. This means that strong inflationary pressure causes consumers to make important changes in the type of foods purchased, which can impact the propensity to consume higher quality products. Basically, food consumption patterns depend upon two factors: quality and price. In Italy, this is also related to the co-existence of great prosperity and poverty.

II.1 The rise of large retail chains: technological implications

Large retail chains (LRCs) serve as intermediaries between consumers and food companies. The pressure on the food sector to meet new technological needs has come in part from the LRCs and their expansion in Italy. This is attributable to their role as intermediary and transmitter of information from consumers to producers, but above all it is due to their strong market power and the competitive pressure that they exert on the food sector, spurring companies to constantly seek out economic efficiency and innovation.

The importance of the LRCs as a channel for selling food in Italy still lags behind the European average but is expanding rapidly, albeit with substantial regional differences. In 2005, 51 per cent of the €105 billion generated by food sales was spent at LRCs.[27] This percentage is well below that of other major European countries (on average over 60 per cent), the United States (around 73 per cent), Australia (over 75 per cent) and some developing countries.[28] Compared with the other countries, in Italy the market share of traditional retail food stores remains high, driven in particular by the South, as we shall see.[29] A comparison of the data on the market shares of prepared foods via distribution channels with other major European countries in 2005 shows that, in Italy, smaller retail outlets account for a significant portion while hypermarkets continue to hold a share significantly below the average of a selection of European countries (Figure II.2).

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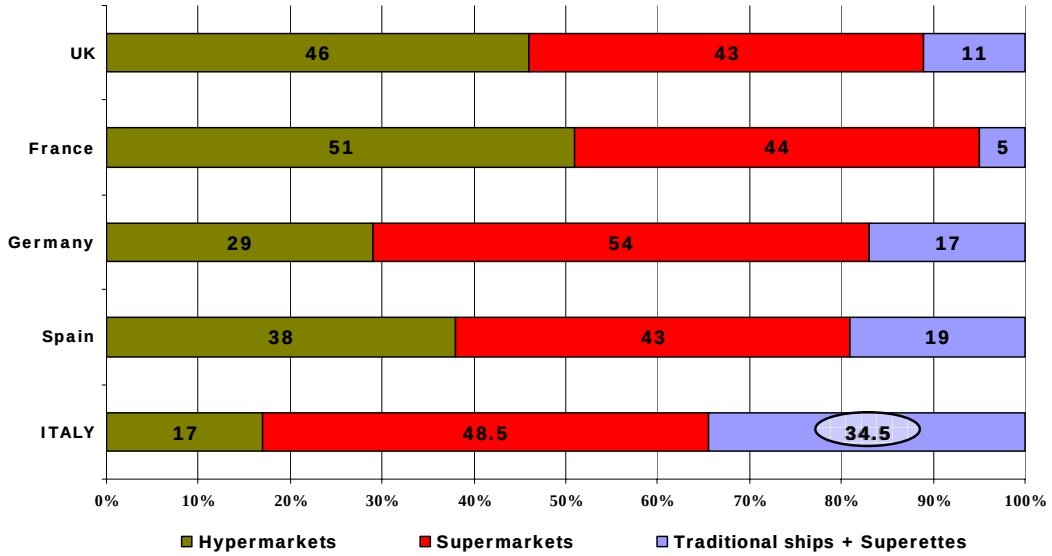
[26] ISTAT, *I consumi delle famiglie*, 2004.

[27] The importance of LRCs is even more apparent if we look at the precentage of domestic purchases by volume by Italian households. The rate of these purchases made in supermarkets and hypermarkets has risen significantly, from 59 per cent in 2001 to 64 per cent in 2005. Ismea, *Rapporto Annuale* "*Evoluzione del sistema agroalimentare italiano*", volume I, 2006.

[28] In 1990 in Latin America, LRCs controlled 20 per cent of the distribution of food products, in 2001 this percentage had risen to 60 per cent (Reardon, Berdegué, 2002). See also Fulponi L, "*Changing Food Lifestyles: Emerging Consumer Concerns*" 2004 - OECD.

[29] Ismea, *Rapporto Annuale* "*Evoluzione del sistema agroalimentare italiano*", volume I, 2006.

Figure II.2 Market share of food sales by LRCs in selected European Union countries (2005)

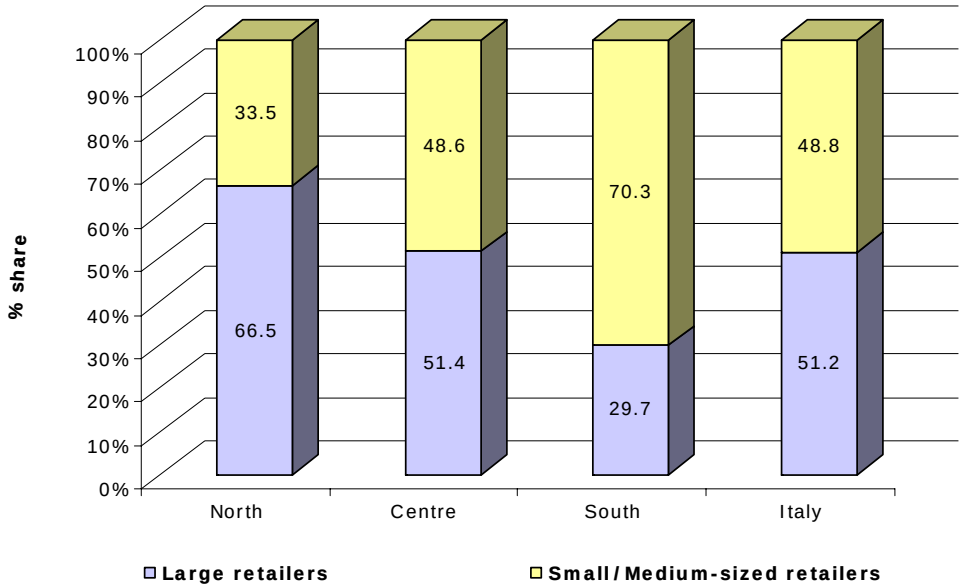


Source: UVAL based on Federdistribuzione data, "*Mappa del sistema distributivo italiano*" published in Ismea, *Rapporto Annuale*, 2006.

However, an examination of food-sector revenues generated by distribution channel over the last ten years in Italy shows that the percentage of food sales by traditional grocery stores has fallen steeply, while the market shares of supermarkets and hypermarkets have increased, driven particularly by sales by hypermarkets, which doubled between 1996 and 2005.[30] A breakdown by territory for 2005 clearly shows that large retail chains play a more important role (with 66 per cent of grocery sales) in Northern Italy, while they account for just 30 per cent of sales in the South, where traditional stores and outdoor markets still account for 70 per cent of food sales (Figure II.3). A comparison of the various parts of the country in terms of the surface area of LRCs per 1,000 inhabitants shows that LRCs are best established in the North and that they are structurally weak in the South.

[30] Consumer focus on price has led to a growing number of discount grocery stores, i.e. small/medium-sized grocery stores (around 500 m²), that have built their business on low prices. Their product range is restricted to the bare essentials and they offer very few well-known brand name products. The most common, simplest form is the 'hard disount' store, while the more recent higher-quality version is the 'soft discount' store.

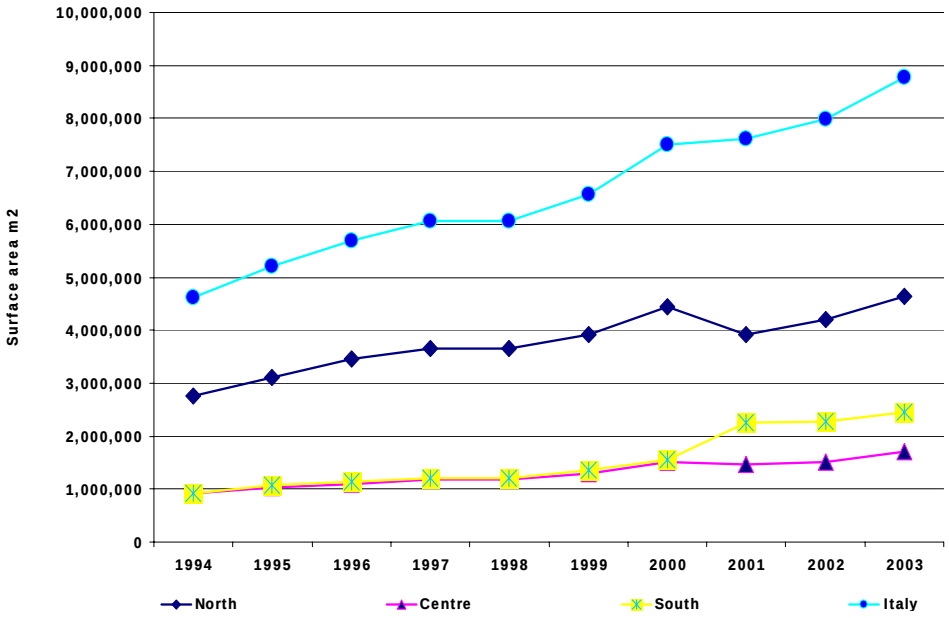
Figure II.3 Market share of food sales by LRCs in Italy in 2005



Source: Based on data from Ismea, *Rapporto Annuale* "*Evoluzione del sistema agroalimentare italiano*", volume I, 2006.

From a dynamic point of view, the data show that LRCs are becoming more well-established in Italy. The number of supermarkets and hypermarkets is rising across the country, with signs of strong growth from the South in recent years (Figure II.4). [31]

Figure II.4 Size of supermarkets and hypermarkets in Italy. 1994-2003 (square meters)



Source: Based on Inea - Nielsen data

[31] INEA, *Rapporto Annuario dell'Agricoltura Italiana*, volume LVIII, 2004.

Differences in the penetration level of LRCs may be accompanied by differing needs for new technologies. In the South, where small retail (e.g. outdoor markets) sales predominate, the introduction of technologies for preserving food and preventing potential food risks are key. In fact, the trust that consumers have in their vendors is of paramount importance. Moreover, since the sales relationship is more informal, this may mean that there is less control of the quality of food products compared with those distributed through a concentrated, structured logistical organisation. In the North, where LRCs dominate, the crucial contractual relationship for modern agro-food distribution is that between the LRC and its suppliers.

Achieving quality standards is becoming an essential requirement for a product find space on shelves, in order to consistently satisfy consumers' increasingly demanding requirements in the necessary quantity. LRCs act as an intermediary between consumers and the agro-food industry. In order to guarantee a high-quality food product throughout the entire year, LRCs enter into detailed contracts with suppliers with a range of production and/or processing specifications. For example, contracts may establish the sowing schedule and the type of seeds to be used, the physical characteristics of the product,[32] the quantities and frequencies of periodic deliveries and deliveries over the course of the year, the type of wrapping and packaging and the preservation method. These are all needs that require constant updating of technologies, especially those related to the traceability of food products, the improvement of preservation techniques, including for fresh products, and packaging. In conclusion, LRCs are expanding in Italy despite the strong position of small retail stores, particularly in the South, where they are nevertheless spreading at a fairly rapid pace. What follows is an analysis of the implications of these trends for technological innovation.

II.2 Links between consumption trends, lifestyles and new technologies

There is a reciprocal relationship between socio-demographic changes, changes in lifestyle, food consumption trends and the spread of new technologies. The constantly shifting demand for food products influences the players along the entire agro-food chain, who seek to adapt to this change by testing and deploying new technologies in the various stages of the production process. All this occurs with the intermediation of the large retail chains.

[32] This criterion is used for fresh food products.

Partly in response to the high level of competition, the agro-food sector uses new technologies not only to meet modern consumer needs but also to anticipate them.

The increase in the average age, i.e. the growth in the population over 65 years of age, has influenced dietary preferences designed specifically to meet health needs. These consumers tend to select products that are most appropriate for the type of diet they want to follow and that are best suited to their physical condition. This has spurred research into creating "designer" products, also called novel foods, light or enriched (fortified) products, and products with therapeutic features (Chapter III).

Concern for the health implications of foods has led to a further segmentation of food consumption, requiring the development of new products. Research has led to the creation of "functional" foods, or food that, at least in the mind of the consumer, facilitates certain physiological functions or has a therapeutic impact. One typical product, perhaps even the most commercially widespread, is probiotic-fortified yoghurt.[33]

Other studies have instead focused on the field of disease prevention or cure through diet to limit the onset of certain conditions and, above all, to reduce the use of pharmaceuticals. In this area, as in the previous one, certain directly involved technological fields, such as biotechnology and genomics, are making a considerable contribution. There are numerous potentially interesting examples, although they are all still at the experimental stage. These range from genetically modified varieties of tobacco containing active ingredients for the treatment of lymphoma to varieties of rice containing the anti-cholera vaccine or proteins that reduce the effects of dysentery, especially in young children. Then there is the well-known example of Golden Rice, which is of particular interest to developing countries since it has a high beta-carotene content and is therefore useful in countering pathologies caused by vitamin deficiencies.

Nevertheless, it must be acknowledged that the contribution of biotechnology and nutritional genomics to satisfying this general demand for products with high nutritional and health properties is still largely only potential. There are various reasons for this. First, they face many practical challenges (the Golden Rice case is again emblematic given the restrictions that it places on diet to be able to be even partially effective).[34] Second, despite the demand trends outlined above, it should not be forgotten that

[33] This is a novel food with probiotic functions, i.e. with health-promoting and disease-preventing characteristics.

[34] In order to receive the right amount of vitamin A, an adult would have to consume about 8 kilograms of cooked rice per day. Considering that this vitamin can only be absorbed by humans in the presence of fatty substances (oils), this creates another problem given that the diets of those in poor countries typically lack sufficient fat.

consumers, particularly European – and Italian – consumers, have a considerable aversion to the use of modern biotechnology in the area of agriculture and food. Thus, while these technologies have great potential, their actual value for agriculture and food production has to be evaluated on a case-by-case basis.

With the increase in the number of households consisting of single persons and single family nuclei, there have also been innovations in the area of "single-serving" packaging. Such consumers also tend to watch their diets out of aesthetic concern about maintaining their figures, which has driven demand for so-called 'light' products, such as supplements, energy drinks, fibre-rich products and protein bars. Among the products with high added value and high service value demanded by singles and others are precooked and frozen foods and all freshly prepared foods, for example, pre-cut washed salad and pre-cut washed and dressed salad. These products represent an important revenue source for the food industry (8 per cent of total revenues).[35] Their popularity is also associated with the more general contraction in the time available to prepare meals, which has led to rising demand for semi-cooked and frozen foods. As a result, there has been growing pressure on the food industry to develop highly specialised methods and techniques for ensuring a high degree of preservation of products without diminishing their quality. Consequently, the demand for advanced preservation and packaging techniques has expanded. This evolution in demand has spurred the industrial research and packaging fields to focus on finding solutions for ensuring optimal product preservation by tracking advances made in protective materials and gas permeability. Research has focused on the development of "food contact film", the ideal solution for preserving the organoleptic properties of foods. There is a varied range of techniques currently available, which are selected on the basis of the specific requirements of the different segments of the agro-food sector.

The push to develop new packaging and preservation technologies is also connected with the advent of new lifestyles and the growth in the consumption of meals outside the home. This has proven fertile ground for the formation of catering businesses and the growing success of fast-food outlets, snack bars, restaurants and cafeteria-style dining, all major consumers of semi-cooked and heat-and-serve ingredients and food products. This has prompted researchers to focus on technological innovations in food packaging, leading to the use of machines for vacuum-sealing products along processing chain. The vacuum-seal process ("form-fill-seal"),[36] is a horizontal system for packaging

[35] Federalimentare, 2006.
[36] This preserves the quality of the product without requiring any further processing since it only has to be reheated.

liquid, creamy, fresh and long-shelf-life products in order to maintain the quality of the product. It is used for the large-scale production of refrigerated and non-refrigerated foods targeted at food-service businesses, restaurants and cafeterias (Box A).

Box A – Product innovation: packaging and fast meals

The rise in the number of people who prefer a "fast" meal has stimulated demand for ready-to-eat products (prepared snacks) and products packaged in thermoformed trays that can go straight from the oven to the table. Examples of innovation achieved through advanced packaging technologies include:

- "smart" packaging, i.e. systems that record a thermal profile (time/temperature indicators - TTI), provide logistical information (radio frequency identification - RFID**) and provide instructions on the content of the package, vacuum techniques and so on;
- the vertical bag packaging system used for the cook-chill process, a process in which food is cooked in a conventional manner then rapidly chilled;
- trays with total oxygen barrier properties*** and vacuum skin packaging. This technique has two fields of application: the vacuum skin with an automatic valve for releasing steam and the "heat and serve" vacuum skin, which allows the product to be processed, transported and sold in the same packaging.

Technological innovation has proven to be a key factor in the development of these new products. This is an example in which agro-food is a sector that generates demand for innovation in other sectors (i.e. active rather than just passive spill-over). In this case, innovation goes through the packaging industry and the use that it makes of specialised equipment, such as automated packaging and wrapping machines. In fact, the agro-food industry is the sector that makes the greatest use of this technology, followed by pharmaceuticals, cosmetics, chemicals and petrochemicals.

* The use of this innovation is connected with the level of collaboration between the food industry, the packaging industry and LRCs (the closer the connection, the greater the use).
** Radio Frequency Identification.
*** Technique used for products with a long shelf-life (months).

We have already noted the growing category of consumers who pay closer attention to food quality and safety and the rising importance of product labelling.[37] The need for the food industry to provide detailed information on fresh and processed foods has encouraged a close collaboration between the bio-chemical and genomic industries and the agro-food sector. This synergy makes it possible to quickly inspect foods, since access to a genomic map of food products facilitates traceability. Specifically, the molecular study of the DNA[38] of foods has produced a number of different applications, such as detecting the presence of chemical substances in foods, natural substances, harmful organisations such as bacteria, toxins (proteic and other) and allergens. In particular, fruits and vegetables

[37] According to a study by the Istituto di Ricerche Economiche e Sociali (IRES), 87 per cent of Italians are concerned about food safety. Nevertheless, it is important to bear in mind that, as emphasized repeatedly here, while consumers may state that they are concerned about food safety, they tend to prefer lower-priced products.
[38] This technique involves the identification of special nucleotide probes, which are used to reconstruct specific fingerprints and identify which micro-organisms may be contaminating the foods inspected.

can be tested for the presence of pesticides, spices and cereals for mycotoxins[39] and foods of animal origin for dioxin residues.[40] The technique can also be used to prevent the formation of mould. The use of traceability techniques is also important for those consumers who, as we have seen, are particularly concerned about the health aspects of what they eat. With the percentage of people affected by food allergies or intolerances on the rise, many studies have focused on creating "replacement" foods with the same nutritional value as the non-tolerated food using genetic reconstruction techniques.

Finally, as we have seen, food quality and market segmentation are only two of the major factors in the competitive dynamics of the agro-food industry: price still remains a key driver. To guarantee safe foods at low prices, existing innovations for the food system must be used effectively. Price takes on even greater importance if we consider the growing proportion of food in being sold through large retail chains, which are a powerful impulse behind the introduction of new technologies in the agro-food sector. Although researchers and analysts are fully aware of the impact of LRCs on innovation in the agro-food sector, the direction in which LRCs are steering that innovation is controversial and must be assessed from the perspective of the various markets involved.[41]

It is, however, acknowledged that large retailers implement commercial strategies that focus mainly on three areas: lowering prices (setting initial prices at discount price levels), satisfying latent demand and introducing new products. These goals force the chains to be more severe and rigid in evaluating the efficiency of the agro-food system in order to improve critical issues, such as ensuring food quality by tracing the food product from its origin through the entire production process (both directly, i.e. from farm to fork, and indirectly, i.e. from fork to farm), and food safety.

Examples of innovations used in ensuring direct traceability are nano-technology applications, such as the Electronic Nose, which mimics the function of the human nose.[42] This technology consists of a database of chemical "sensors" that can identify

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[39] A substance produced by certain fungi that causes toxicosis (a condition caused by the presence of toxic substances in the blood coming from outside the organism or produced within the organism itself) in humans or farm animals.

[40] A highly toxic, non-biodegradable chemical compound.

[41] For example, recent studies have shown that the growing concentration of LRCs and their dominant role could have a chilling effect on product innovation in the food industry (Weiss and Wittkopp, 2005).

[42] The Department for Development Policies has launched a pilot programme to finance a series of advanced technology projects in the South. One of these, "Time-Technologies and Innovation for the South", a project presented by the National Institute for Materials Science (INFM), looked at the use of nano-technologies in analysing and measuring the healthiness of food products. INFM, along with the SENSOR laboratory in Brescia and in collaboration with the La Doria firm of Angri (Salerno), built and tested an electronic nose prototype (olfactive sensors) to test the quality of fruit and

the basic composition of odours, processing the information gathered, providing a detailed, exhaustive description, and storing and communicating the data easily. The tool is used to detect the presence of contaminants (or other defects) in food, to ensure product quality and its stability over time and to verify compliance with the quality standards established by the food industry and/or the LRC. It is used above all with fresh foods, such as fruit. In another example, NIRS (Near Infrared Spectroscopy) uses the same principle as the Electronic Nose for this purpose. This technology, drawing upon information contained in a database on the qualitative characteristics that a food must possess, makes it possible to determine the exact moment at which the product must be harvested (rationalisation of harvesting), the most appropriate preservation technique and, especially for refrigerated products, the ideal time for removing the food product from the cold room.

These new technologies make it possible to offer uniform products, to adopt new marketing strategies and to certify the traceability of the zone of origin of the processed or fresh product.[43] Their potential range of application is enormous, particularly for fraud prevention, which is important in an agro-food system like Italy's, where the focus is on high-quality production and certification of origin.

vegetable products (tomatoes in this case). Testing is currently being conducted on the use of this tool with fruit juices. These experiments place Italy on the cutting edge of the field, since it is the only country that is carrying out this type of testing.

[43] These techniques are currently used to determine the area of origin of olive oil, apples and peaches.

III. The Italian agro-food system's propensity for innovation[44]

Price remains a crucial factor for competition in the agro-food industry. However, market differentiation and segmentation strategies are becoming increasingly important. More demanding consumers and greater focus on the characteristics of food products (hence the current labelling and traceability efforts) are prompting the agro-food industry to make significant organisational changes and to invest in and develop production processes capable of offering new products with special characteristics, all while maintaining price competitiveness. A better understanding of consumer buying behaviour, and the key role played by the large chains (especially in areas where they have a significant presence) in setting food quality standards, means that producers are being spurred to offer tailored products for a highly segmented market even in product areas historically viewed as traditional and undifferentiated. In order to offer products that meet various consumer demands (naturalness, functionality, convenience), producers must use new technologies and apply innovations in research and development at different levels of the production chain.

International, intersectoral and intertemporal comparisons of "innovative performance" are anything but easy and, consequently, the findings are sometimes ambiguous. Their reliability depends upon the indicators used, the homogeneity of the sources used to construct these indicators and the very availability of data. Nevertheless, questions about the level of technology and propensity to innovate of a productive sector in a given country must be addressed, especially at a time when it is believed that the ability to compete on a global scale hinges on the capability to privide answers. The technological level of the agro-food sector can be measured with a variety of indicators (total factor productivity, labour productivity, the intensity of spending on research and innovation and patent output). A starting point in any analysis is total factor productivity (TFP). For Italian agriculture, comparison with other countries over time shows that Italy's primary sector does not rank among leading countries in terms of technology (i.e. those with the highest TFP), nor has the significant growth over the last few decades been sufficient to close the gap with these leaders (Schimmelpfenning and Thirtle, 1999). Basically, Italian agriculture is located in the "follower" group (or "adopters", in the terminology of the neo-Schumpeterian literature; Spielman, 2006b), i.e. countries whose TFP growth follows on the coattails of the leader

[44] For more information see the *Rapporto Annuale 2005* of the Department for Development Policies on programmes undertaken in Under-utilised Areas, Section II, paragraph II.4.2, pp. 152-163.

countries (or "innovators"), although it retains a structure lag that has never been fully bridged. Italy is behind countries such as the Netherlands, the United States and France, for example, and on equal footing with other "follower" countries such as Spain and Germany. Moreover, if measured in terms of agricultural labour productivity, the gap with respect to other European countries, and other national sectors, is even clearer (Esposti, 2004b). As there are currently no valid international comparisons of TFP for the food industry, we cannot state with certainty that the Italian food industry shows an analogous lag behind the leader countries in terms of TFP. However, if we restrict this discussion to the comparison of labour productivity, the evolution of which often parallels that of TFP by virtue of the fact that technological progress is primarily labour-saving, one finds that the situation is not open to easy interpretation. Table III.1 shows that average firm sizes in the Italian food industry are well below the European average and, in a national setting, smaller than in other manufacturing sectors. At the same time, however, labour productivity is in line with other countries of similar size and level of economic development (Spain and France), and higher than the European average.

Table III.1 Comparison of countries by size of firm and labour productivity (VA = value added): EU25 = 100. 2003 data

	Manufacturing (total)		Agro-food	
	Workers/Firms	VA/Workers	Workers/Firms	VA/Workers
Germany (excluding former German Democratic Republic)	235	122	154	97
Spain	77	93	80	106
France	98	113	60	109
Italy	58	91	39	107

Source: UVAL based on Eurostat data

What is even more striking is the performance of the sector compared with the Italian manufacturing sector as a whole. With labour productivity slightly above the average for manufacturing, and despite the firm size problem, in recent decades - and at least until the 1990s - the food industry has registered faster growth in TFP than most other Italian manufacturing sectors (Atella and Quintieri, 1998).

It is appropriate to conclude that, from both an inter-sectoral and an international standpoint, what holds for agriculture does not entirely hold for the food processing industry. On the contrary, there is a lack of empirical evidence for labour productivity, and presumably TFP, that unequivocally demonstrates a significant lag with respect to other manufacturing sectors and the more technologically advanced economies. It is therefore puzzling that this sector is frequently lumped together with agriculture as one

with limited development and low technological dynamism, i.e. a low-tech industry (Mohnen *et al.*, 2006). In realty, this view is the product of other considerations.

III.1 Research for the agro-food industry in Italy

A further indicator used to measure the innovation performance of the agro-food sector of a country is spending on research and innovation. In this case, too, international comparisons are a challenge. Each country, in fact, has its own system of agricultural research and innovation, with different levels of involvement of public and private participants. The agro-food sector is marked by low intensity of research and development, if compared with other industrial sectors. This is also why, in Italy as in many other countries, the role of public research is very important. In fact, since the agro-food industry is characterised by small agricultural firms, and by an ever more polarized industry composed of either small or very large food companies, public research can compensate for the lack of research in the primary sector and its weak presence in the investment of food companies.

The issue is made even more complex by the fact that horizontal integration (cooperatives, consortiums, and associations of producers) or vertical integration (for examples, contracts among various levels of the system) can facilitate investment in research,[45] and that agriculture itself uses innovations developed in other sectors (for example, by suppliers, such as chemical or pharmaceutical companies). Frequently, this sort of integration is not revealed in statistical data. In turn, the food industry produces a range of diversified, innovative products for which investment in research cannot always be specifically distinguished. Thus, at present, the statistics do not capture all the work actually being carried out by the agro-food sector in this area. According to international statistics, the intensity of spending on research and development by Italy for agro-food amounted, in 2004, to 1 per cent of agricultural value added, well below the level of more innovative countries, and relatively constant over the last ten years (Table III.2).[46] Of the countries analysed, only Greece has a lower intensity than Italy. In addition, compared with other countries, and in line with research and development spending in general in Italy, there is a low rate of participation by private players.

[45]These phenomona cannot currently be measured, since the Italian statistical system does not yet report R&D spending by agricultural firms.

[46] However, bear in mind that the statistics on public research in Italy for the agro-food industry reported in international databases are underestimated since they do not include R&D spending by universities.

Table III.2 Spending on agro-food research (public and private) on Agricultural Added-Value: European comparison (percentages)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
France	3.6	4.0	3.5	3.9	3.8	3.4	3.4	3.4	3.6	3.1	3.1	3.3	3.7	4.2	3.6
Germany	n.a.	3.1	2.7	3.1	4.6	4.9	4.2	4.4	4.0	4.0	3.8	4.0	4.3	4.6	3.5
Greece	n.a.	n.a.		0.3	0.2	0.4	0.4	0.4	0.3	0.4	0.3	0.8	0.3	0.7	0.4
Italy	**0.8**	**0.8**	**0.8**	**0.8**	**0.7**	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.9**	**0.9**	**1.1***	**1.5***	**1.2***
Netherlands	4.2	4.2	4.0	5.1	4.3	4.5	4.1	4.0	4.0	4.7	4.6	5.5	6.1	5.7	4.8
Spain	0.8	1.0	1.0	1.1	1.1	1.2	0.9	0.9	1.1	1.1	1.2	1.1	1.4	1.5	1.9
United Kingdom	4.8	4.9	5.7	6.0	5.9	5.0	5.7	5.5	6.0	5.8	6.3	7.0	6.2	6.4	4.9

Source: UVAL based on Eurostat data (government budgeted spending - GBOARD) and OECD data (private expenditure of the agriculture and agro-food sector - RDS 2005)
* Public spending for the agricultural sector, 2002, 2003 and 2004, ISTAT figures.

In Italy, total spending on research and development by the public and private sector in 2004 came to about €305 million, of with €204 million[47] for public research and €83 million for spending by food companies. The total amounts to 1.2 per cent of agricultural value added.

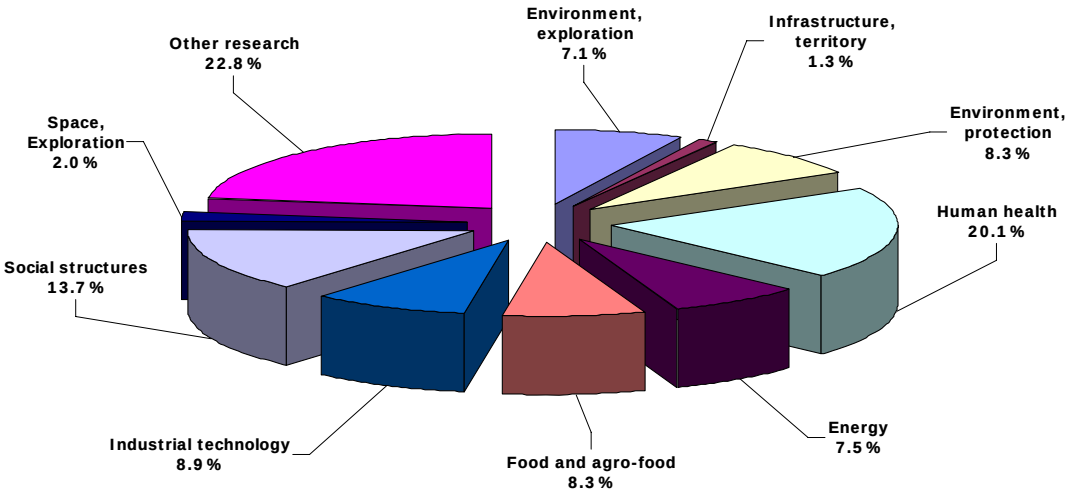
Box B – Public and private spending on agro-food: a comprehensive reconstruction

Until 2000, Italy's National Agricultural Economics Institute prepared and published an estimate of total public spending in Italy on agro-food research. This estimate drew on the accounts of various public agencies and research institutions and the reports of funding programmes for agricultural research, estimating spending by universities (only for agriculture and veterinary departments) on research and development, following the guidelines set out in the Frascati Manual. The reconstruction differs from that obtained using ISTAT data because it is based on appropriations (not spending data) and because it also includes outlays by universities. This method reveals that spending on agro-food research and development amounted to €429 million in 2000. Of the total, about 80 per cent was public research and the rest private research.
The findings confirm the low level of investment by private entities, although an increase was reported, to double the 10 per cent at the start of the 1990s. Given that private spending increased at a much higher average annual rate than public spending and total spending, there was a substitution effect. In addition, distinguishing expenditure by funding entity, in 2000 funding from the Ministry of Education to universities was the highest (46 per cent), following by funding from the Ministry for Agricultural Policy and associated research centres (30 per cent) and by the regions (28 per cent).

Of total public R&D spending in Italy, agriculture and food absorbed a significant percentage (8.3 per cent on average for the period 2002-2004), second only to that spent on protecting human health and on social structures and relations. According to ISTAT data, the amount spent on research for agriculture and food is close to that spent on protecting the environment and the territory and slightly more than that spent for research on the production, distribution and use of energy (Figure III.1).

[47] This reaches €222 million (1.3 per cent of the agricultural value added) if research into nutrition and food hygiene is included.

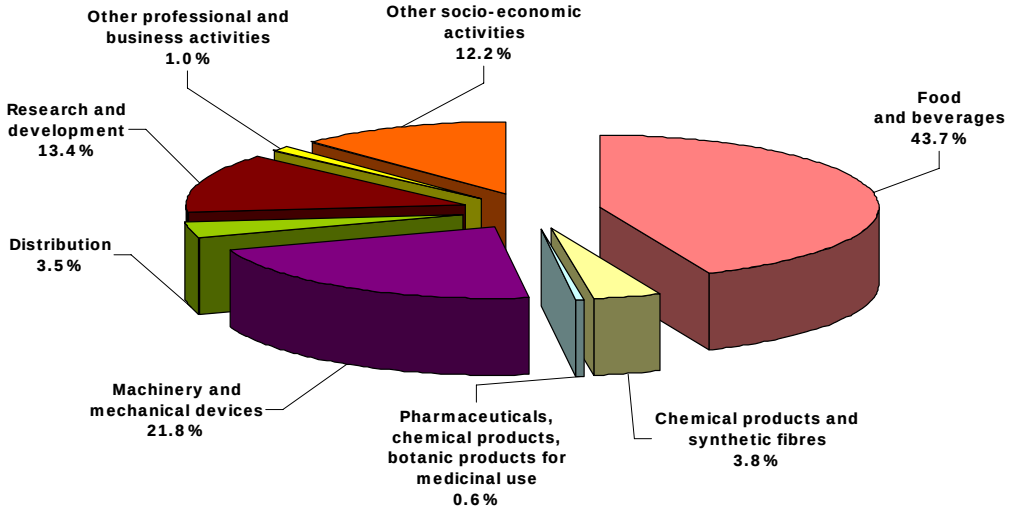
Figure III.1 Public R&D expenditure by socio-economic objective (*internal*) (average 2002-2004)



Source: ISTAT, *Statistiche sulla Ricerca Scientifica*, 2002-2004

Food companies invested an average of €97 million in R&D during the 2002-2004 period, while the total by all companies (including food companies) in the various sectors that invest in research and development into products of the agro-food chain, was €143 million (Figure III.2). The component from the other sectors therefore accounts for 60 per cent of purely sectoral investment.

Figure III.2 Expenditure of different sectors on agro-food research products (2002-2004 average)



Source: ISTAT, *Statistiche sulla Ricerca Scientifica*, 2002-2004

As to R&D spending by food companies in the different areas of the country, companies in the North-East are highly active. The situation in the South is especially worrying: despite the fact that 42 per cent of local units of the Italian food industry are located here and around 22 per cent and 40 per cent of the food and agricultural value and 30 per cent of national farm exports originate in the South, only 8,2 per cent of research expenditure by food companies is attributable to this region (Table III.3). This is reflected in the lower contribution of this area to the formation of national food value added and in its weaker presence in total exports of higher value added products compared with undifferentiated goods. Due to problems with how these statistics are constructed, it is not currently possible to conduct a geographical analysis of public spending on research for the agro-food system.

Table III.3 Importance of agro-food sector and R&D spending by food companies by geographical area (millions of euros)

	Agricultural value added*		**Food value added***		**Agricultural exports****		**Food exports****		**No. of local units of the food industry*****		**R&D spending by food companies**	
	2006	%	2004	%	2005	%	2005	%	2004	%	2004	%
North-West	5,654	20.8	7,109	34.1	760	18.4	6,120	37.1	16,887	21.6	20.1	24.8
North-East	6,535	24.1	6,233	29.9	1,631	39.5	5,808	35.2	15,732	20.2	49.3	60.9
Centre	4,332	15.9	2,873	13.8	518	12.5	1,952	11.8	12,540	16.1	4.9	6.0
South	10,607	39.1	4,628	22.2	1,219	29.5	2,613	15.8	32,897	42.1	6.6	8.2
Italy	27,159	100	20,844	100	4,130	100	16,497	100	78,056	100	80.9	100

* *Source*: UVAL based on ISTAT data, chained values (reference year 2000)

** *Source*: UVAL based on ISTAT data for foreign trade

*** *Source*: Based on ISTAT data for industry and services (ASIA – local units)

III.2 The innovation strategies of food companies in Italy

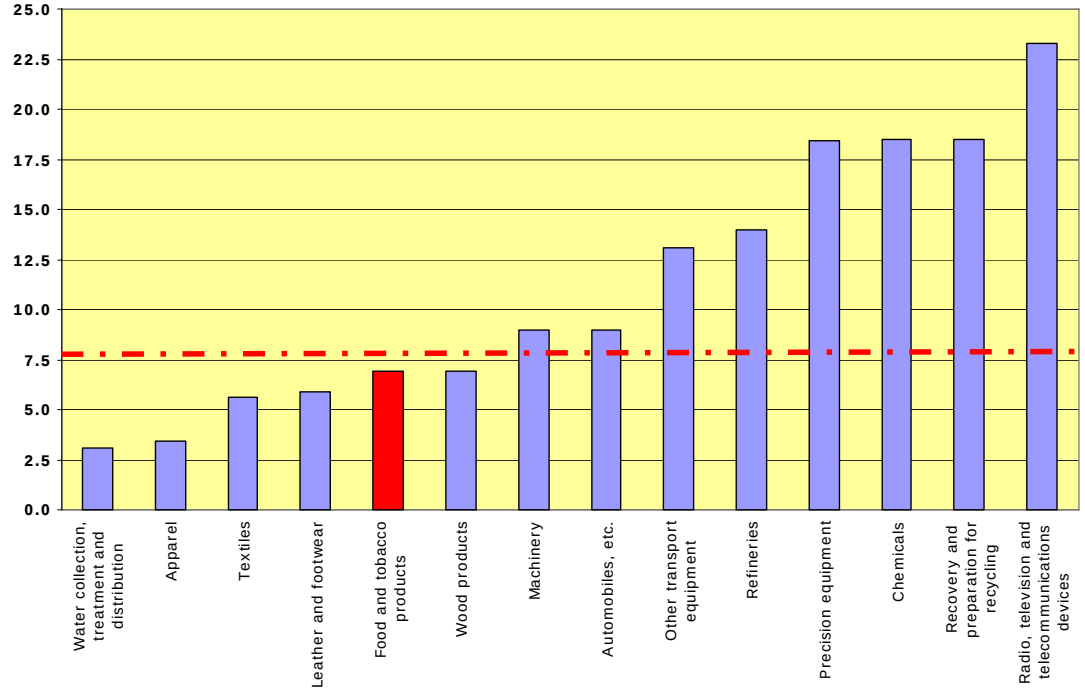
Agro-food firms are adopting innovative strategies in response to changes in the behaviour and preferences of consumers, who are increasing looking for "services". As discussed in Chapter II, the nature and content of these services change depending on the characteristics sought by consumers. At the level of primary production, the application of new technologies that, for example, ensure traceability could be decisive. At the level of food processing companies, innovation may be linked to the use of new

technologies and the development of new products, thanks to improvements in product packaging or preservation techniques, for example.

In Italy, there is a shortage of economic analysis of these issues. It is true that there is a problem in defining, and therefore measuring, the phenomenon. Various studies have compared the level of investment in R&D by the food sector with that of other industrial sectors. Other economists have held that only looking at research and development spending is inadequate, since many innovations in the food sector are "incremental" and this translates into slight improvements in products that cannot be measured merely by looking at formal research spending. Still others consider promotional spending and branding strategies to be more indicative of the level of innovative differentiation in the food industry. Finally, it is possible to use patent data, but many innovations concerning agricultural and food products are not patented and/or cannot be patented. As far as statistics go, in Italy we can obtain data on the level of investment in research and development of the agro-food sector, as well as ISTAT's surveys of innovation by firms and patent data from the national and European patent offices. The level of R&D in the Italian food sector is far below that in high-technology sectors (e.g., telecommunications, chemical and pharmaceutical products). After all, private research in Italy is highly concentrated within large companies, and the food sector is still dominated by small and medium-sized firms. As might be expected, almost all the research spending by food companies is targeted at experimental development (51 per cent) and applied research (48 per cent).

According to ISTAT sample survey data, the agro-food industry's level of spending on innovation is higher than the average for various manufacturing sectors and for other so-called "traditional" and "undifferentiated" sectors, such as the textile, clothing and wood products industries. Spending on innovation by the Italian food industry is higher in absolute terms than that by the pharmaceutical sector and is 60 per cent of the total spent on innovation by the chemical products sector - two industries traditionally considered to be high-tech (ISTAT 2003). However, if one looks at the average spent per worker, the food industry is below the average for the various manufacturing sectors, although still above the traditional, low-innovation sectors.

Figure III.3 Spending on innovation per worker by industrial sector (2004, thousands of euros)



Source: ISTAT, *Statistiche sull'innovazione delle imprese*, 2002-2004

The ISTAT survey also shows that of the total food firms included in the sample, 32.4 per cent are considered innovators, a slightly lower percentage than the average for the entire industrial sector. The percentage of companies that introduce innovations rises with their size - 31 per cent of small companies are innovators, compared with 74 per cent of large companies. If the percentage weight of SMEs in the Italian agro-food industry is considered (54 per cent in Italy and about 70 per cent in the South), it is clear that the biggest problem lies in getting SMEs involved in innovation processes. From this standpoint, it is particularly worrying that only 5 per cent of innovator food firms have formed cooperation arrangements for innovation (compared with a still rather low 8 per cent average for industry in general).[48]

Looking at the "type" of spending on innovation, in the majority of cases it focused on process or mixed innovation, while the remaining is directed at product innovation. Simple forms of innovation predominate, such as the purchase of machinery and plant to improve production processes. From this point of view, the food industry behaves

[48] The ISTAT study provides information on collaboration agreements between innovator companies with outside parties in a context of the exchange of scientific knowledge and technological expertise. These can be public or private bodies. (customers, suppliers, consulting firms, competiters, universities and research institutes). 1998-2000 figures.

just like undifferentiated and low-diversification industries. In fact, investment in research, both internal and acquired, is low, as is spending to acquire technological know-how in the form of patents and/or licenses. Finally, a particularly unexpected finding is the low investment in marketing technologically new products (9 per cent) and in training personnel made necessary by the adoption of new productive processes.

At the international level, a recent European study presented by Federalimentare (Smes-Net, 2006) once again shows that Italian food companies are the least intensive investors in research and have the lowest propensity to innovate in Europe: 24 per cent of Italian companies in this sector have not introduced any innovation over the last 3 years, while the corresponding European figure is just 15 per cent; the percentage of companies that have introduced significant process or product innovations is 41 per cent in Europe, but just 33 per cent for Italy (Table III.4).

Table III.4 Classification of industrial firms in the food sector by propensity to innovate

	Innovators				**Developers of innovations introduced by others**	**Non-innovators and non-developers**	**Total**
	Process	Product	Both	Total			
EU	23%	31%	13%	41%	44%	15%	100%
Italy	20%	24%	11%	33%	43%	24%	100%

Source: UVAL based on Smes-Net data, 2006

In terms of patent production, in 2003 Italy accounted for 9 per cent and 14 per cent, respectively, of the total agricultural and food patent applications in the 15-member European Union. Germany holds the largest percentage of patent applications, while Italy has a larger share than France. It should be pointed out that Italy's share of agro-food patents is much higher than its performance in patent applications in general (7 per cent). Of the total patent applications recorded by the European Patent Office for Italy in 2003, the agro-food industry accounted for 2 per cent. Within the European Union, there are, however, countries for which the percentage of agro-food patents is higher (Denmark, 7 per cent and Spain, 6 per cent). On the other hand, the small percentage weight of patent applications in this sector is not fully indicative of its importance, since innovations in agriculture are not always patentable and there are special registers for new varieties of fruits and vegetables and breeds of animals. Moreover, for food products, the maturity of the industry means that companies rarely seek patent

protection, while the value incorporated in knowledge, accumulated know-how and incremental innovations are protected mostly through branding.

To conclude, the statistics considered here are insufficient to analyze the innovative practices of agricultural firms. However, some evidence has emerged from the spread of innovation in the agricultural area. For example, just 1.7 per cent of agricultural firms in Italy are computerised, and these are located primarily in the Centre-North (62 per cent), with the rest divided equally between Central and Southern Italy. The same territorial disparity can be seen in Internet usage by agricultural firms. On the other hand, given that various studies have shown how the primary factors driving the adoption of new technologies in agriculture are mainly tied to the socio-economic level of farmers (younger people with a medium-high level of educational attainment), it is understandable that Italy lags behind, since it has one of the highest rates of aging farmers in Europe, with a serious deficit in educational attainment.

IV. Trends and limits in current R&D and innovation policy

There is a consensus in the scientific literature that growth in the agro-food industry over the last century is largely attributable to the great progress made in scientific and technological research and innovation in this field (Box C). However, analysts also agree that the final outcome in terms of the positioning of a country to compete in the international technological realm is a systemic result, and so not attributable merely to a single variable, a single actor, or a single economic policy decision. In other words, it is the result of a long-term process in which a variety of components and actors have forged networks of interaction and integration in the creation and adoption of knowledge, human capital and technological innovation that, in this specific case, concern a country's food and agriculture industries.

Box C – Slow Magic: the role of research and innovation in the growth of the food and agricultural industry

The empirical evidence regarding the contribution of research and innovation to agriculture is extensive and, essentially, in agreement. Hundreds of studies concerning both developed and developing countries, and both public and private research, have shown that the contribution of investment in research to productivity growth in agriculture is quite high (Alston et al., 2000). The social rate of return (i.e. in terms of growth in overall well-being) has also been significant (at just under 50 per cent taking an average of the figures reported in the literature), although this emerges over long and uncertain timeframes (Pardey & Beintema, 2002). Focusing on agro-food research and innovation continues to be one of the key "recipes" for solving the problems of underdevelopment (World Bank, 2007).

It is also true that alongside this undoubted contribution to growth in productivity and, therefore, in output, the role of agricultural research and innovation from a more general social (employment in particular) and environmental point of view has been the object of numerous critiques, particularly with regard to the introduction of new plant varieties (Manenti, 2005; World Bank, 2007).

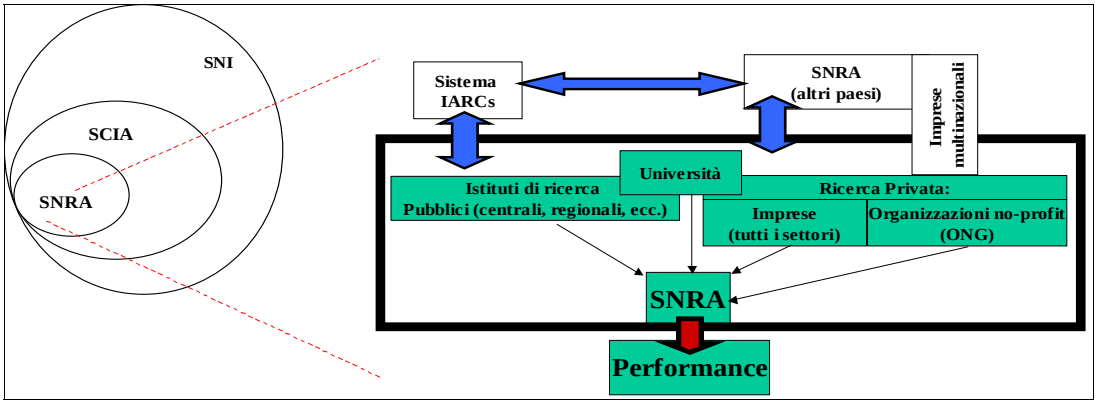
Moreover, while on the one hand this broad body of empirical evidence was initially a strong argument in favour of the hypothesis of insufficient investment in public agricultural research, the focus quickly shifted to understanding the mechanisms that actually generate these high levels of return and social benefit. In fact, the figures concern both public and private research, and both basic research and technological development and its dissemination for agriculture, but public investment in research still requires long periods of time to generate positive results and is in any event conditioned by a significant degree of uncertainty. Thus, in recent years this rich empirical literature has, above all, been interpreted in terms of the need to understand "how" to allocate public resources in this area and "how" to design the system of research and innovation in agriculture, rather than on "how high" the optimal level of investment is (World Bank, 2007).

Various labels have been attached to this system. Perhaps the best known is the National Agriculture Research System (NARS), which is in turn the industry-specific offshoot of the more general National Innovation System (NIS) (Spielman, 2006a; Garonna & Iammarino, 2000). According to the FAO's definition, a NARS in a given country is the set of all public

and private institutions and actors that dedicate all or a part of their resources to research and development of agricultural, or more broadly agro-food, technologies, based on the strategic priorities of that country, i.e. in accordance with its own agriculture research "agenda". To each of these components of the NARS, we can also add the efforts of analogous entities in other countries or international bodies (e.g. the International Agricultural Research Centres, or IARCs), which lie outside the decision options of entities in the NARS but, at the same time, can significantly affect those options.

More recently, this systemic view of the innovation performance of a country and an industry has been linked more closely with the processes and mechanisms for transferring knowledge, hence we speak of the Agricultural Knowledge and Information System (AKIS) (Spielman, 2006a). The key point here is that the innovation performance of an agro-food system such as Italy's is not merely the result of public policy decisions *per se* (e.g. deciding how much to spend on public research), but rather is the outcome of how these policy decisions are coordinated and integrated with each other and with the efforts of the other actors involved in the system (Figure IV.1).

Figure IV.1 Stylised representation of a NARS and its relationships with AKISs and NISs



Source: Esposti, R.: "Public agricultural R&D design and technological spill-ins. A dynamic model". *Research Policy*, Vol. 31 (5), 693-717, 2002.

It is fair to ask how the Italian NARS is structured and how it works, what its strategic objectives are and, in that regard, what role is assigned to the actors involved and to the policy decisions, and, above all, whether such objectives and policy decisions are still consistent with a changing context. In light of the above, one fundamental question concerns the strategic decision for the country's agro-food system to take either a position of technological leadership or play the role of a "follower".

In that regard, and particularly in relation to the general design of the system of public research in Italy (Bonaccorsi, 2003), the impression one has is that of a decision that has never been definitively taken. On the one hand, empirical evidence would suggest that the Italian agro-food industry has taken a back seat, at least as far as the primary sector is concerned. At the same time, however, within the decisions on the use of (limited) public resources, we find a highly fragmented, inorganic structure. It is highly dispersed at the geographical and so apparently in touch with local needs, but at the same time still dominated, particularly within academia, by the thinking typical of unfocused research, unconnected with applications and poorly integrated downstream with other components of the NARS or with users. Research funding is therefore inadequate and, above all, too fragmented to hope to establish technological leadership, but at the same time there is an inadequate allocation of resources to the typical "follower" efforts to adapt and apply technologies (Esposti, 2002; Esposti & Pierani, 2003).[49] Efforts to develop, adapt and transfer technologies would require focused; and constantly monitored, use of resources, which is in practice missing. Instead, resources are dispersed among many research efforts, which often have no specific objective and are not integrated with each other, at times resulting in the duplication of spending and failing to achieve the sort of critical mass that could trigger the processes of aggregation and economies of scale that are typical of knowledge creation (Sterlacchini, 2004). In light of the above, one could ask whether, for Italy's NARS, a "hybrid" approach might be more appropriate, i.e. one that acknowledges the inability to achieve global technological leadership in many industry segments (e.g. grains, meat, milk) – and for these seeks to strengthen connections with leading countries, research facilities and businesses and enhance the ability to adapt technologies – while at the same time also aspiring to be a leader in certain segments (e.g. fruits and vegetables, olive oil, wine) that are seen as being of strategic importance to Italy's positioning in the global marketplace.

On the other hand, the comparative advantage that the Italian food and agriculture industry appears to have on international markets leverages aspects such as local origin, quality, tradition, and a culture of fine cuisine, which are highly specific and held in

[49] A distinguishing feature of the NISs and NARSs that have, or aspire to, positions of leadership is the formation and continuous updating of a body of accurate information and statistics on research and innovation. Conversely, in Italy it appears that this achievement is a distant prospect, whereas it should be one of the primary objectives for their redesign. Despite the studies that ISTAT conducts in this area, it is still difficult to construct a comperhensive framework of information. Only recently, the CNR published an interesting collection of statistics from various sources that seeks to provide this unified view (CNR, 2007). However, the sectoral detail remains highly limited, and a complete body of statistics and other systematic information on Italy's NARS is still lacking.

common by a dense system of SMEs. Such advantages therefore require a substantial rethinking of the contribution that research and innovation can provide. While in many developing countries, or even those advanced agricultural systems, this contribution remains focused essentially on increasing yields and on the cost savings generated by the broader scale of production, in Italy's case innovation must also focus on strategic aspects such as traceability, logistics and marketing. In other words, it must focus on highly intangible aspects where there is much room for innovation that is also largely unexplored and in which few other agricultural systems have an interest in penetrating.

The need for a hybrid approach for a country such as Italy and its agro-food industry, and thus the need to overcome the schematic dualism that this entails (e.g. basic research vs. applied research; public research vs. private),[50] would also seem to be supported by a series of changes in context that are making the adoption of one of these strategic alternatives even more difficult to pursue, albeit for different reasons.

First of all, since the late 1980s, all the leading countries have been modifying the strategic focus of their NARSs. There has been a reduction, in real terms, in the funding of public agriculture research (Spielman & von Grebmer, 2004; Huffman & Just, 1998; Huffman, 1999; Pardey et al., 2006) in most of the countries. Secondly, these diminishing resources tend to be directed towards new priorities (the environment, product quality and quality of life, sustainability, rural development and tourism, etc.) where, however, the results are less amenable to generalisation, less transferable and less adaptable, given that they are more specific to a given context. Conversely, many leading countries are increasing funding for public basic research, particularly if linked to the development of general-purpose technologies that can be used in a much broader, even unlimited, range of economic and other activities. The agricultural application of such technologies is being passed on to other components of the NARS, with a more limited potential for dissemination to and adaptation for other agricultural contexts. These changes in the "leader" countries risk making the role of "imitator" or "follower" more difficult, in that the technological spillovers and potential for adaptation are diminished.[51] In addition, the adoption of these new general-purpose technologies (biotech, ICT, micro- and nanotechnologies) makes a purely adaptive approach more difficult and costly. First of all, it requires a greater effort in terms of "absorption capacity". Indeed, public basic research once again becomes of

[50] See also Garonna & Iammarino, 2000.

[51] Indeed, in some of these "follower" countries, such as Italy itself, we are seeing a tendency to imitate the leader countries in, for example, reducing investment in real terms in public research in the food and agriculture industry where, given their different initial positioning, they should actually be doing just the opposite.

central importance with these technologies even for adaptive functions, given that their novelty and scope renders the traditional division between science and technology, i.e. between pure research and application, even more blurred and, in fact, virtually non-existent in terms of skills and human capital. The level of knowledge and skills that they require is in fact especially high even for applications.[52]

Secondly, the development of these technologies has been accompanied by stronger, more complex intellectual property systems, which make adaptation and adoption by followers more difficult than it once was.

This has also occurred because there has been a sharp increase in these leading countries in public-private partnerships for technological research and innovation (Spielman & von Grebmer, 2004). It is not that such partnerships are, in practice, crucial to the leadership status of these countries, as this is above all due to their massive level of high-quality "public" (although not necessarily conducted by public bodies) basic research. Nonetheless, as noted, in the case of food and agricultural research, these partnerships enable public and basic research to "step back" partially from the realm of technological and commercial development, which is instead handled more by the system of large multinationals, or even by specialist SMEs with highly skilled human capital and technological capabilities. Indeed, the affirmation of this collaboration between the public and the private in the leading countries was not deliberately designed or determined by some economic policy decision, but rather arose naturally within the development of the system itself thanks to the arrival of new technologies that fostered academic spin-offs, the hiring of researchers by businesses, greater circulation and, also, codification of knowledge, and more extensive use of complex intellectual property systems. The development of such partnerships has lagged far behind in Italy due to the structural limitations that can be found on both sides, and which are therefore not easily resolved with changes in direction by the public sector alone.

It is precisely in the agro-food sector and in a country that wants to continue being a "follower" structurally that such public-private integration should be increased, involving the rest of the system, first and foremost the large retailers. The LRCs now directly control a portion of food and agricultural production through the creation of their own private labels, the penetration of which is still limited in Italy (at between 10

[52] For this reason, the development of applications first comes about directly from the system of public or basic research, as academic spin-offs, which are often a necessary step before moving from the research labs to the production labs and to commercial development.

per cent and 15 per cent), but which will likely reach the same level as in other European countries (around 25 per cent on average).[53]

Large retail chains are now the main means of transferring new demand from consumers and the distribution and restaurant industries themselves to the food industry. It is also true that the multinationalisation that LRCs are experiencing can "displace" innovative decisions, both public and private, for a country. Italy's large retailers in particular show very limited penetration in foreign markets, whereas the presence of various forms of foreign large-scale distribution in Italy continues to rise. The great impetus that LRCs impart to innovation and the high degree of standardization that it transfers upstream as a result tends to transfer decisions and strategies to Italy that were actually made elsewhere, making the direction of the very evolution of the system largely exogenous.

IV.1 Public agro-food research in Italy: opportunities and risks

In light of these general trends, we must now seek to understand what the best strategy is for developing Italy's NARS and, in particular, for the components that depend most directly on economic policy decisions. To do so, we must take account of the limitations mentioned above, in particular limited private research and the poor integration between private and public research. In turn, public research has a major component, the universities, which absorbs a significant portion of public resources but which operates under highly self-referential governance and organisational arrangements that are unresponsive to external stimuli for change and unmotivated to achieve greater integration with the other components of the system. The second component of the public agro-food research system commands a substantial portion of total resources but is made up of myriad governmental and regional research centres characterised by the high fragmentation of their financial and human resources, with poorly coordinated objectives and a high degree of geographical dispersion that does translate into equally close ties to the specific needs and opportunities of the territories in which they operate. In other words, it is a geographically dispersed system that answers to central government more than to the needs of the communities in which it is located.

These contradictions in the public, non-national research system, and agro-food research in particular, are not new and are well known (Pennacchi, 2005). In fact, they

[53] See Bergès-Sennou F., 2006, "Store loyalty, bargaining power and the private label production issue", *European Review of Agricultural Economic*, Vol. 33(3), pp 315-335.

have even been acknowledged in recent attempts to reform policy and institutions in this field. The main, indeed indispensable, role that public policy must now play in food and agriculture research and innovation in Italy is to remedy these structural limitations.

The determination of the scale of resources, strategies for their allocation, and monitoring and evaluation procedures should all be configured so as to resolve the contradiction between this highly fragmented supply incapable of responding to specific local needs and an ever more locally-focused, specialised demand.

Italy can aspire to a position of leadership in certain narrow areas and, at the same time, seek a more active, effective capacity for adaptation for the rest of the country's food and agricultural industry. In order to develop and combine these two strategies, a number of guidelines can be identified (Pardey et al., 2006). First, it would appear necessary to achieve greater autonomy for Italy's NARS, i.e. to endow it with a greater capacity to develop its own lines of research without having to focus solely on the development of external research and innovations, especially by identifying segments in which a position of technological leadership would be of greatest strategic importance to the country. Thus, what is needed is a NARS that places greater emphasis (and not just resources) on basic research, with a focus, above all, on general-purpose technologies, as this is the foundation for establishing leadership in the country's areas of specialisation (e.g. olives and olive oils, wine, fruit and vegetables), as well as a greater ability to actively apply innovation coming from the outside. Finally, we need a NARS organised on more effective "network" lines, with stronger links between the various component parts, seeking to reduce overlap and competition (not in the sense of scientific competition, but rather competition for the same resources and objectives) and to increase cooperation and complementary efforts.

From these guidelines spring four priorities for economic policy in research. First, it is necessary to increase investment in research in this sector. Although it is perhaps overemphasized by the scientific community in particular, we cannot escape the problem of the inadequacy of current funding and human capital in pursuing any strategy beyond maintaining the status quo, which, as noted, already shows clear signs of inadequacy in a much changed landscape. Second, and most importantly, these resources need to be targeted more closely towards the ultimate objectives of the NARS. This means selecting research priorities; ensuring, where necessary, economies of scale and appropriate specialisation; rationalising the multitude of existing research

centres; fostering the creation of research capabilities in the private sector; and enhancing links between the private and public sectors.

Third, more attention needs to be paid to managing intellectual property rights. This is not a matter of increasing the level of patent protection for innovations, nor of limiting the openness of research, particularly when backed by public funding. Rather, the problem involves giving the various components of the NARS better tools to manage ownership issues, particularly with regard to obtaining access to knowledge and innovations from the outside and in adapting and developing them for the Italian context (Esposti, 2004a).[54]

Finally, more tools are needed to promote private-public, public-public and national-international partnerships: we need to strengthen the incentives and disincentives that would support the "networking" of the various components both within the NARS and with the outside world.

International benchmark models for the "network" organisation of an NARS are difficult to find. Indeed, the networking of research and innovation that also involves a variety of actors (from scientists to farmers) has mainly been emphasized in developing or recently developed countries (e.g. Central and Latin America), with the intent of developing an alternative solution to the creation of highly hierarchical systems with excessive public control, a model that has failed in many other contexts and also comes with costs and a level of organisational and institutional complexity that often only leader countries can manage. The World Bank (2007) has discussed several interesting experiences of creating networks in research, innovation and dissemination. At the level of high-end research networks, one notable example is the Consultative Group on International Agricultural Research (CGIAR), which has played a significant role in coordinating, promoting and disseminating the work of international centres for varietal improvement, in part through local partnerships. Finally, among countries with advanced agricultural systems, the land-grant system in the United States, established over a hundred years ago, is a useful point of reference (Committee on the Future of the Colleges of Agriculture in the Land Grant University System, 1995).

[54] For example, the creation of public-public or public-private partnerships for accessing knowledge and innovations exempt from proprietary restrictions, as they would be intended exclusively for research and not for commercial development (i.e. material transfer agreements); promotion of the development and adoption of open-source technologies and systems; the acquisition of skills - even to the extent of establishing dedicated offices and departments – in analysing access limitations and procedures in the presence of ownership restrictions (e.g. defining freedom-to-operate procedures).

Beyond consideration of broadly analogous experiences in networking found in other countries, the network model for rethinking Italy's NARS can, nonetheless, be a useful point of reference – a point of compromise between two extremes, neither of which is workable and both overtaken by the current developments, a "third way" (Spielman & von Grebmer, 2004; Bonaccorsi, 2003). At one extreme, we have a highly centralized, hierarchical system (e.g. along the lines of the French or Dutch models) that calls for a very high level of public investment, unlikely in the short term, and a significant overhaul of the existing fragmented organisation, which is probably not feasible politically. It is also a system that pursues what is perhaps an overly ambitious strategy, i.e. achieving overall technological leadership in the agro-food industry, a goal which that lies beyond Italy's reach and perhaps not even in the country's best interests. At the other extreme lies Italy's current system, which is unable to channel such scattered efforts towards focused strategic goals and which, while perhaps capable of generating excellence, is not able to forge this excellence into a system or to engender virtuous circles that foster "best practices" and reward results and merit (Box D).

Box D – Governance of Italy's agro-food research system

This current fragmentation or, better, atomisation could also represent a starting point, an opportunity to create this "network" system. It is probably easier to do so from these conditions than it would be starting from a highly centralized, hierarchical system. The challenge is precisely that of redesigning the system, and public food and agricultural research in particular, so that the existing organization acquires the positive aspects of modularity and flexibility, rather than the negative aspects of dispersion. Nonetheless, such a conversion into a "network" system would require a number of institutional steps, which would be without cost but not necessarily painless. The first step is the inevitable process of selection and downsizing, given that it is not possible to retain all current facilities. We must focus resources by reducing the number of facilities and promoting the expansion of the best. The second step consists of fostering greater and improved cooperation among institutions. In a "network" system, there is no hierarchy of universities, non-university government research, regional facilities and enterprises. At the same time, within this model, overall strength is generated by the intensity (in both quality and quantity) of the relationships between the various nodes of the network. Accordingly, the sharing of resources, human capital, knowledge and skills among all of these communities as peers needs to be significantly enhanced.

Last but not least, greater integration with the National Innovation System is necessary. The many points of intersection between the National Agriculture Research System and the other components of the National Innovation System (the universities, for example) are such that it would not be possible to redesign them separately.

V. Conclusions

In recent years, the food consumption patterns have undergone significant changes due to demographic, economic and lifestyle developments. Although a certain segment of consumers has gained a heightened awareness of high-quality goods, price remains an essential driver of food purchases. This has generated significant competitive pressures in production, thereby creating demand for advanced technologies but also the need to adopt innovation strategies. The demand for new technologies is also heavily influenced by the spread of new lifestyles and the growing presence of large retail chains in Italy.

Accordingly, the capacity for a country to produce research and innovation that is of use to food and agricultural enterprises, and more generally to cost reduction strategies (and more efficient decisions) throughout the system (including transport and logistics),[55] is key to the competitiveness of the industry and to the growth of the country, notably those areas in which the agro-food system could help to bridge the economic divide (such as Southern Italy). After having established the main lines of development of these new opportunities and new needs for technological advances, we then sought to determine the propensity for innovation within Italy's food and agricultural industry by looking at a range of available indicators, also taking account of the propensity for innovation of food companies themselves.

The situation in the case of agriculture is fairly clear, in that a comparison with other countries over time demonstrates that Italy's primary sector cannot be considered a technological leader, but is rather part of the group of "followers". This is confirmed by the gap in agricultural labour productivity compared with the other countries. The situation in the food industry is less clear. Even limiting ourselves to a comparison of productivity, the situation is not easy to interpret. The average size of firms in the Italian food industry is well below the European average and, within Italy, below that in other manufacturing industries. At the same time, however, productivity is in line with other countries of similar size and economic development (Spain and France) and greater than the average for Europe.

The tendency in economic literature to consider the food industry as a low technology intensity sector, along the same lines as agriculture, stems from an oft misunderstood correlation between productivity and the effort expended on innovation as measured by

[55] Strategy tied to the market of origin and destination of the goods and to the optimal use of existing flows of goods.

conventional indicators, particularly research intensity. In fact, not all innovation generated in the food industry passes through investment in research and development and is, by nature, often incremental innovation. It is true that the intensity of research in Italy's agro-food sector is below the European average, and far below that of the leading European agricultural countries (such as France). The situation that emerges is one of a system of prevalently public research with low levels of investment, albeit in line with Italy's lag in terms of total R&D investment as a proportion of gross domestic product. The participation of the private sector is also low, although in the agro-food industry this is partly explained by the prevalence of small and medium-sized enterprises and the low degree of integration of public and private research.

Improvement is also needed in terms of the type of spending on innovation, which is mainly focused on traditional forms of innovation, such as purchasing new machinery. More sophisticated expenditure, such as marketing innovative products, is still markedly insufficient. But given the fragmentation of the country's agro-food sector and the fact that the impact on revenues of the adoption of innovation strategies for smaller firms is significant,[56] it is necessary to create and promote forms of cooperation and network approaches to innovation. Finally, investment in the development of human capital is essential to revitalizing an industry in which the strategies for innovation are held back by inadequate levels of education and a worrying aging of practitioners.

With regard to economic policy strategies, with the exception of certain strong segments in which Italy still plays a driving role (such as farm equipment and wine), Italian research in this industry in general is mainly of an "adaptive" nature, often being limited to transferring the knowledge generated in other countries and adapting it to the various local contexts in Italy.[57] This is a source of concern, considering that the results of this research are being imported mainly from countries with different product specialisations than Italy. Moreover, adapting research done in other countries is becoming increasingly difficult due both to the very nature of the new technologies and the resulting intellectual property issues. Knowing how to create research that meets the country's own needs is particularly important at a time when the transformation of agriculture from a highly subsidised industry to a more market-oriented sector will require further specialisation of the agriculture industry in Italy's areas of comparative advantage. Products that are a part of

[56] See ISTAT study of innovation in business, *"Impatto dell'innovazione sui risultati economici e sull'attività aziendale"*, 1998-2000.

[57] Esposti, presentation on public research in agriculture, *"Ricerca Pubblica in agricoltura: risultati, tendenze e prospettive"*, seminar on research and innovation in agriculture, INEA, 16 December 2005.

the Mediterranean diet and products with greater value added will play an increasingly important role. The extent of this role will depend on expanding the segment of consumers who are able to demand quality and services beyond a mere niche market, a process which is linked to the level of education in Italy and the ability of education to narrow wealth disparities and ensure higher average incomes.

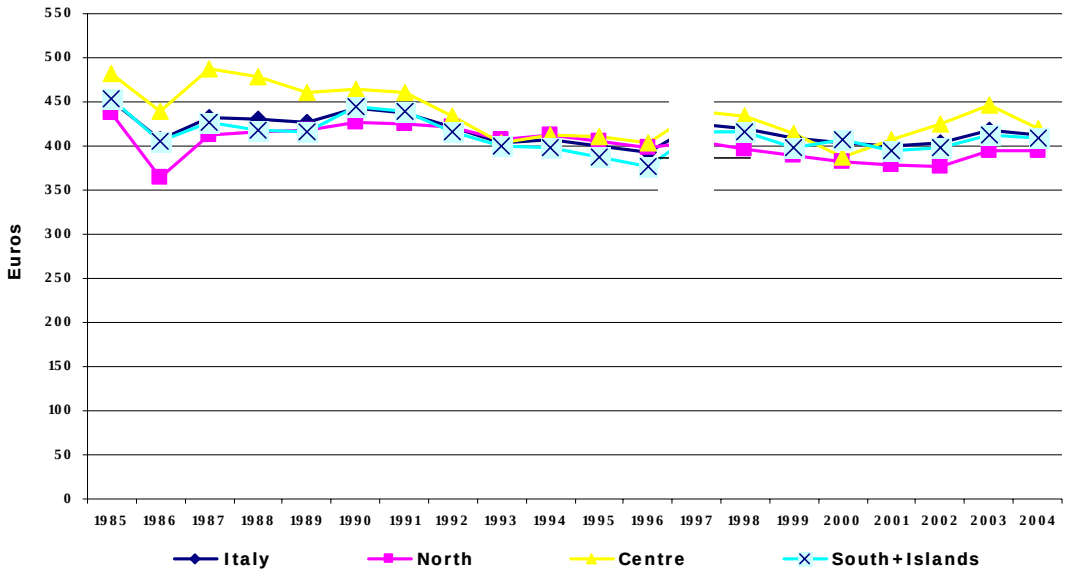
Many of the products that are destined to play an increasingly important role - including as a proportion of total exports - in Italy's food and agricultural industry (such as quality wines and classic local Italian products), output of which remains limited, will still require the fundamental contribution of public research, but also the promotion of "networked" research initiatives that will enable enterprises operating in the same or synergistic sectors (e.g. chemicals and food) to create and use research together. This is particularly true in areas of the country where agriculture is important not only in terms of value added and the creation of wealth, but also in terms of its contribution to the attractiveness of the territory. From the standpoint of integrating this sector with the territory in a broader sense, it would appear to be essential to at least undertake active adaptation research, in which the technology transfer takes account of the specific needs of local territories.

It is also true that the opportunities connected with the development of research services in support of the food and agricultural industry do not depend solely on the volume of public funding, but also on two other important factors: the capacity of research bodies to generate quality research; and the ability to create the appropriate mechanisms for the transfer and actual use of the results of this research within the private sector. Therefore, the efforts already begun, at both the local level and elsewhere, to create mechanisms that facilitate the matching of research supply and demand are significant.[58] Finally, the contribution of the broader private sector (i.e. agricultural enterprises, food companies and other sector businesses whose research could have an important impact on the food and agriculture system) must also be leveraged.

[58] For example, the research intermediation agencies that already exist in certain regions.

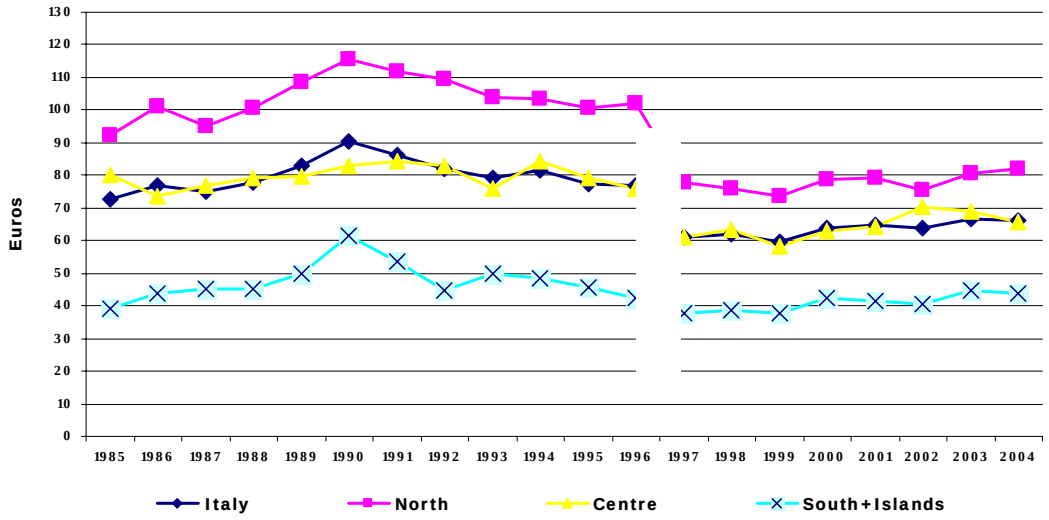
Annex A – Consumption and large retail distribution: geographical analysis[59]

Figure A.1 - Aerage monthly expenditure on food by geographical area 1985-2004



Source: Based on ISTAT data, household consumption survey, 1985-2004

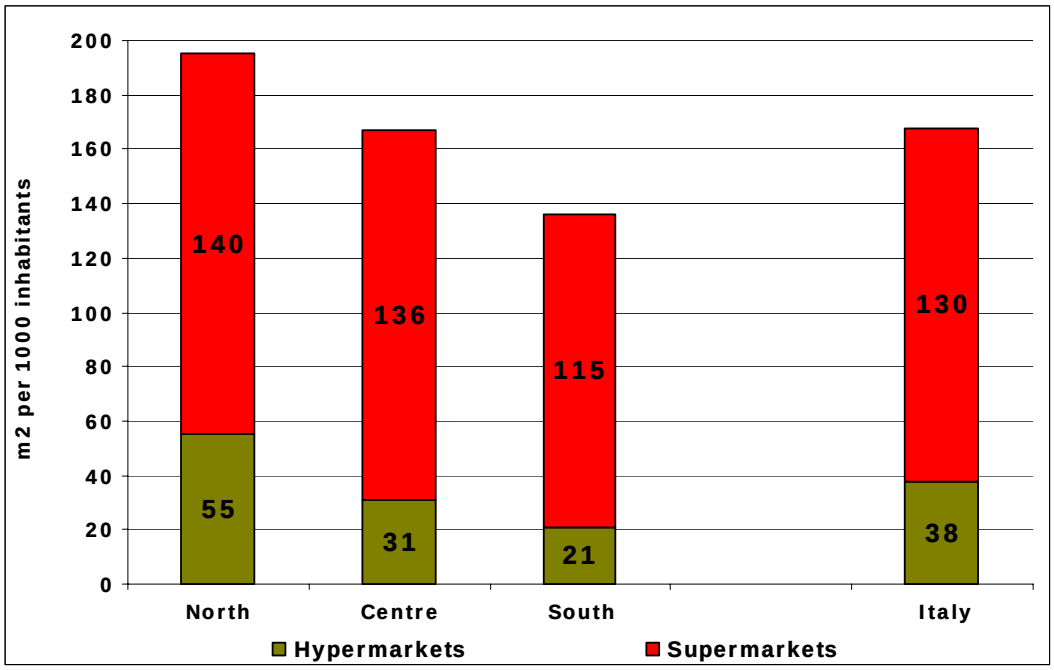
Figure A.2 – Average monthly expenditure on meals outside the home by geographical area 1985-2004



Source: ISTAT data, household consumption survey, 1985-2004

[59] The methodology used by ISTAT in its survey on household consumption was modified in 1997. Accordingly, Figures A1 and A2 report developments in average spending by households on food products and meals consumed outside the home based on the two methodologies using comparable series. Therefore, the time series has been split in correspondence with the year in which the new methodology was adopted (1997).

Figure A.3 Surface area of hypermarkets and supermarkets by area of the country (2005, square meters per 1,000 inhabitants)



Source: Based on Federdistribuzione data, *"Mappa del sistema distributivo Italiano"*, october 2006.

Annex B – Selected examples of new technology applications

B.1 Examples of the application of new technologies at different levels of the system

B.1.1 Upstream actions for organising and implementing targeted raw material production

The new technologies available at this level of the chain are genomics, biotechnology and nano-technology. Genomics has a variety of applications. The most common applications in the agro-food field concern traceability, quality control and food safety. For example, genomics is used to evaluate risks connects with the presence of chemical substances in foods and/or to monitor the nutritional characteristics of animal feed, to prevent disease and risks linked to the deterioration in the quality of the final product.

Nutritional genomics also includes recent efforts to build "designer" foods that are particularly beneficial for consumers, for example, who suffer from conditions such as food allergies and intolerances. Biotechnology, using specific genetic mutations at the input level (for example, with seeds), can facilitate the production of certain foods in adverse conditions, such as farming in particularly arid climates.

Technologies and machinery can make it possible for farmers to target, as far as possible, their output *ex ante* in relation to the changing needs of the consumer and the environment (bearing in mind the uncertainties and risks to which agricultural production is subject as a result of its vulnerability to increasingly uncertain weather conditions). They also have an impact on controlling product quality and quantity (precision agriculture, pre-determined agriculture, using biotechnology to adapt products to different environmental conditions). The wine sector offers an example of interesting applications of new technologies, having long adopted winter pruning as well as green pruning and mechanized suckering, techniques that make it easy to eliminate shoots and buds that spring up around the vines, robbing the plant of water that is crucial to the quality of the final product. The citrus fruit sector also uses mechanized pruning. In recent years the grains sector has been using the sod seeding technique, which allows the soil to be worked without tilling.[60]

[60] This technology was much used in the United States in the 1980s, although it has only recently been introduced in Italy. It promotes the retention of moisture by the soil in areas where precipitation is scarse, such as in the South.

B.1.2 Flexible organisation of food processing

The technological innovations introduced in this stage of the chain have been largely centred around ensuring the quality and traceability of products for consumers. For example, in the oil sector, there has been growing use of the two-phase oil extraction method, which preserves a high level of polyphenols (anti-oxidants). This satisfies the demand of consumers who are concerned about a healthy diet that features extra-virgin olive oil, one of the traditional components of the Mediterranean diet. In the wine sector, special technologies have been introduced for various types of wine, particularly those used to control the temperature (high for white wines, temperate for reds), which is important for ensuring standard product quality. Stainless steel refrigerated vats have been introduced at the preservation stage. Since these are more hygienic, wine cellars can be located above ground and temperatures can be kept constant more easily, and quick action can be taken when problems are discovered. Nano-technology, an excellent example of which is the electronic nose, have also found a place in the agro-food sector. The electronic nose can be used to analyze the quality of fruit and its degree of ripeness, or to identify disease in asymptomatic plants.

B.1.3 Logistics

A series of technological advancements has made logistics processes more efficient. In the nano-technology area, near-infrared spectroscopy (NIRS) devices, which use electromagnetic and optic principles along with a database of the various quality criteria, can be used to determine the best time for harvesting, the strategies to implement and the best preservation techniques. This means that large quantities of standard-quality fruit can be brought to the market, indicating the level of ripeness reached at the time of harvest or upon leaving the cold room. This technique improves marketing strategies and the traceability of the zone of origin of the product, whether fresh or processed. These technologies are also used to improve logistic processes for olive oil by making it possible to determine the ideal moment to harvest the olives.

New techniques developed by the packaging industry to make it easier to move and store food without damaging the product are among the innovative technologies that have improved logistics.

With the growth in demand for frozen products, the food industry must contend with the problem of sudden changes in temperature during transport of foods from the

distributor to the distribution chain. The taste of food products can change, and health risks emerge, if food products are not maintained at a constant temperature during transport. Therefore, certification of the cold chain has also been introduced. This is a system for recording the internal temperature of the delivery vehicles to ensure that a constant temperature is maintained. An example of this is a data logger, a device developed to automatically read the temperature and measure and record the physical parameters of temperature and humidity during transport, in storage rooms and in the distribution and transport of meals.

B.2 Examples of innovations in the primary sector that have been applied in other sectors

B.2.1 Bio-energy

The bio-energy sector offers farmers new market opportunities. In fact, certain raw materials can be used to produce fuel. Rising oil prices and diminishing supplies have prompted many researchers to look to for a better way to use annual and perennial crops to produce energy. Biodiesel is produced using oil seeds and waste vegetable oils; bioethanol is produced from starchy or sugary crops, surplus food products, agro-industrial residues and by-products; and biogas is obtained from livestock manure, agricultural residues and agro-industrial waste, organic wastes and solid urban waste. The production of second-generation biofuels, using lignocellulosic biomass, is still being studied.

B.2.2 Use of organic photovoltaic cells

Solar panels made of silicon photovoltaic cells are an example of an alternative energy resource. Silicon shortages and high production costs have pushed researchers to develop less expensive panels that are easy to manage and are environmentally friendly. Electronic engineers have begun investigating how to manufacture solar panels using pigments derived from berries as an active component, thereby eliminating silicon entirely and cutting production and installation costs. The fruit-based pigment absorbs light in the simplest manner possible. The photogenerated electric charge, after various stages, can in fact function like a battery. The solar (i.e. photovoltaic) panel works based on the junction between two semi-conductor materials that permit the current to flow. These panels will come in flexible sheets or plates of semi-transparent glass.

B.2.3 Alternative uses for crops

The polysaccharides obtained from tomato-processing residue can be extracted and purified to make biodegradable plastic bags. The chemical and physical characteristics of polysaccharides extracted from tomato skins can be used to develop a range of bio-degradable materials, such as the sheets used in agriculture to cover greenhouses or fields or environmentally friendly shopping bags. This innovation could help solve the challenges of eliminating food processing wastes, cutting costs and improving the system of gathering and, especially, disposing of waste or unsold residues.

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