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The Historical Development of Industrial and Domestic Food Technologies

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The historical development of industrial and domestic food technologies is partly marked by the promise of modernization, social progress, and an overall better *quality of life* for (particular sections of) the population.[1] This technological determinism is visible in nineteenth-century reformers and feminist utopians proposing automated food manufacturing and centralized kitchens, and in many of the twentieth-century commercial and marketing claims for purchasing domestic technologies or convenience foods (Belasco 2008). The promise of liberating women from difficult, time-consuming domestic chores (e.g., preservation, storage, preparation, and cooking) was one such claim. Whether these considerations reflected real improvements for women has been the subject of much debate driven by feminist technoscience perspectives.

Important, the development of these technologies coevolved with the increasing separation between production and consumption. Entering the twentieth century, these two spheres were geographically and technologically distancing from one another through the lengthening and complexity of food chains. And yet, both were connected through the spaces of intermediation when assembling, marketing, and using technologies for preserving, storing, or cooking food at multiple settings (industrial, commercial, institutional, or domestic).

This chapter depicts the various ways different scholarship strands and methodological approaches have explained and examined industrial and domestic food technologies. It looks at U.S. and European research and also at developments elsewhere. The text follows a science and technology studies (STS) orientation, a perspective that stands against technological determinism and underscores the social and cultural embeddedness of technological artifacts. Having assessed the emergence of research in this broad field, the second and third parts of the chapter present the main tenets of the STS

approach, describing its main concepts to facilitate the examination of three key debates around gender, time, and competence. The chapter closes with a critical appraisal of the direction of recent and future work in the field.

THE EMERGENCE OF RESEARCH IN THE FIELD OF INDUSTRIAL AND DOMESTIC FOOD TECHNOLOGIES

The study of industrial and domestic food technologies has tangentially featured in the pioneering work of social scientists at the turn of the twentieth century (see, for instance, Marx, Veblen, or Schumpeter). These classical texts in social research have, in some way or another, touched upon the impacts of industrialization, urbanization, and technology on factory working conditions and family life. But it was with historians of social history, food, and above all, of technology that a more focused analysis of industrial and domestic food technologies surfaced. Interest in the theme was fueled by the ample transformations that took place during the nineteenth and twentieth centuries.

Industrial Food Technologies

The Industrial Revolution generated a flux of people from the country to the towns (T. Williams 1982). One consequence of this was the increasing distancing of food-producing from food-consuming areas, making crucial the industrial development of technologies of food preservation and storage to guarantee that perishable foods would reach urban consumers in good conditions. With the population growth in towns, food supply concerns mounted (see Scholliers and Van den Eeckhout, Chapter 3, this volume). Technologies of food preservation and storage had not only to be improved and based on the modern chemical industry blossoming throughout the nineteenth century, but new agricultural technologies also had to be developed to substantially increase crop yields. For instance, it was during this time that the use of artificial fertilizers commenced[2]; steam engine machines for plowing, cultivating, and reaping crops were gradually adopted; streamlining and selection of seeds were the object of much experimentation by practicing agriculturalists (Derry and Williams 1960).

Despite the importance of the Industrial Revolution as a turning point to the fast development of industrial food technologies, one may not forget that techniques and knowledge on the best ways to preserve food were already deeply rooted in the food cultures of old civilizations. Several preservation techniques such as salt curing, smoking, wind and sun drying, salting water, pickling in vinegar, or fermentation were already employed by local communities scattered around the globe. The ancient Chinese were proficient in the biochemical process of fermentation applied to the making of rice wine, soya paste, or sauce (Huang 2000). Caves, covered pits, waterproof and insulating natural materials (e.g., straw, clay), snow, and ice were used to control thermal conditions and prevent food deterioration.[3] Honey served to preserve fruits in classical Rome,

and spices were important preservatives in China and India. Fruit bottling was practiced from at least since the seventeenth century, and throughout the eighteenth century, most households were competent in this domestic process. Such expertise paved the way for the preservation of other types of foods (Thorne 1986).

The first attempts at canning were made by the Dutch navy in the middle of the eighteenth century (Thorne 1986). At the beginning of the nineteenth century, Nicholas Appert—a Paris confectioner—invented a new technique to preserve food in vacuum-sealed containers. However, these first experiences often met with poor end results (taste, dangerous working conditions, poor sealing or heating).[4] Pasteur's groundbreaking work on bacteriology in 1861 was crucial for the advances in the canning industry; however this was a gradual process from trial and error to more scientific methods.

At the start, canned foods were mostly used in naval or polar expeditions, and given their dear price, were considered a luxury item only afforded by the affluent classes. In the United States, the Civil War accelerated demand for domestic consumption of canned foods, which further increased with urbanization and advertising techniques that promoted branded processed foods in the United States and Europe (Thorne 1986). From the 1860s the canned meat industry developed in Australia and South America, enabling the export of cheap meat to feed the working classes of European industrial cities. Soon, what was once perceived as an extravagance became an affordable commodity, gradually penetrating food habits of a previously meat-deficient population.[5]

As to the refrigeration system, it had first developed from the natural ice trade. At least since the sixteenth century, ice was transported by animals from the Alps to the Mediterranean countries; however this was considered a luxury item mostly used to chill drinks (Freidberg 2009: 20). Only in the nineteenth century did natural ice became an important market commodity in North America (and also Norway), it being exported to Australia, South America, South Africa, and India (Teuteberg 1995: 52). However, there were negative public perceptions toward cold storage. It was viewed as deceptive freshness and a health hazard because of the potential pollution of natural ice sourced from contaminated waters (Freidberg 2009; Teuteberg 1995: 54). Some of these issues were supplanted by the introduction of artificial cold, which "paved the way for the transition to an efficient mass production" of food (Teuteberg 1995: 57), revolutionizing the organization and scale of production, storage, distribution, and ultimately, consumption. After the first experiments with artificial cold in the 1830s, major developments in refrigeration and freezing systems took place in the second half of the nineteenth century, particularly after World War I[6] (see Horowitz 2006).

A "cold chain" quickly emerged for industrial and commercial use, countervailing the natural cycles of seasonality. However, refrigerators for domestic use were slower to pick up. Only after World War I, images of freshness were popularized through advertising campaigns, government agencies' health propaganda, fridge manufacturers, home economists, and the discovery of vitamins, persuading users of the benefits of cold storage (Freidberg 2009). Together with progress in transport systems, the diffusion of electricity and water infrastructures, changes in food retailing,[7] the feminization of the labor

force, among other factors, the fridge (and the freezer) became a normalized and convenient device in everyday life. However, in rural China for example, the appropriation of white goods was much slower as electricity systems were only installed in the early 1970s (Wu 2008). And even when electricity was in place, the take up of refrigerators was slower in rural China than in urban areas.[8]

The military-industry complex also had a significant role in food innovation. Military technologies put to use in a context of war were applied to the development of commercial food manufacture during the postwar years. The cases of microwave ovens and plastic gadgets for storing food (e.g., Tupperware) are poignant examples.[9] But also food irradiation developed from applications of atomic science to food safety and preservation after World War II. However, commercial and public perceptions of irradiation and its potential lethal effects on humans (after traumatic episodes with uses of nuclear weapons, nuclear plant accidents, and so forth) troubled the acceptance and trustworthiness of this technology among consumers and food manufacturers (Zachmann 2011). The same happened with European consumers' concerns around biotechnology and nanotechnology food applications at the end of the twentieth century.

Over the last decades, research on industrial food technologies has explored risk food issues, food scares, and anxieties in an era paradoxically marked by strict regulations and policies on hygiene and food safety.[10] To placate public anxieties, industrial food companies have put several strategies forward such as the recent investment in the nutrigenomics and functional foods market (Dixon 2009). Functional foods, which first appeared in the Japanese market in the 1980s, are products that claim to have health benefits. Apropos such claims, in the 1990s an intense debate ensued on their legitimacy. After efforts to regulate the global functional foods market, which quickly became encroached by big corporate companies playing in both food and pharmaceuticals fields, the Japanese government has recently signaled a turn in direction by launching the Basic Law of Shokuiku.[11] As explained by Dixon: "Even in Japan, the home of the functional food revolution thirty years ago, there appears to be a subtle turn away from a corporate controlled food system to a food system that is sympathetic to the environment and civic traditions" (2009: 327). Nowadays, industrially processed foods have conquered an ambiguous place in consumers' images and practices: if, on one hand they are tarnished by concerns around food safety, environment, social justice, and health, on the other hand, the flexibility and convenience they enable is a trade-off difficult to live without given the increasingly erratic schedules of everyday life.[12]

Domestic Food Technologies

From the 1970s onward, interest in the historical development of domestic food technologies grew and concerns around the impact of such technologies on women's lives (namely their impacts on women's work-leisure time budgets) emerged. According to Wajcman (2000), the first studies on the history of domestic technology appeared in the journal *Technology and Culture* and primarily focused on a North American context. In

this field, one of the most cited publications is Ruth Schwartz Cowan's seminal history of housework, *More Work For Mother* (1983), which still remains an influential piece. Cowan's historical study of household organization concluded that despite the introduction of domestic technologies and convenience foods, housework has not decreased. On the contrary, while in preindustrial households men, children, and women contributed equally to the normal running of housework (children collected water, men chopped wood for the open hearth, and women tended kitchen gardens and cooked), in postindustrial households, men and children's activities were gradually eliminated (water was supplied by utility services, gas or electricity fed the heating or cooking stoves), and women's tasks increased.

Susan Strasser's historical research *Never Done: A History of American Housework,* matching Cowan's work on prominence and impact, advanced some explanations for housework increase. At the turn of the twentieth century, many middle-class housewives faced the "servant problem." As factory work in urban centers expanded, more working-class women were drawn into industrial production instead of carrying out poorly paid domestic services in middle-class households, augmenting the housework burden of this class (Cockburn and Ormrod 1993; R. S. Cowan 1976, 1983; Levenstein 2003). However, and offering a quick rebuttal, many working-class women's jobs were based on the emergent industrial food factories and food service sector (low skill and repetitive work). Thus, drudgery seemed to have switched venues, from domestic to the industrial sphere, from middle- to working-class women employed in the food industry, retailing, and service sectors.

Rising standards and conventions of food hygiene and cleanliness was another explanation for the increasing housework burden (R. S. Cowan 1976; Oakley 1974). Health professionals and hygienists in the United States and Europe of the late nineteenth century saw the house as a key location to implement their public health doctrines. They were "mesmerized by the discovery of bacteria and the germ theory of disease" (Levenstein 2003: 148), which brought concerns over the cleanliness of kitchens and food hygiene. The dissemination of these ideas was coupled with images of modern and efficient households greatly inspired by Taylorists' positions that considered the home similar to a factory where time, motion, and money were under tight management and control to increase productivity. Thus, the "industrialization" of the domestic sphere was not only enacted by the increasing material presence of processed foods and domestic appliances but also by conventions of propriety on body care and hygiene, nutrition, and health circulated by new professionals[13] (see also Brembeck, Chapter 16, this volume and Smith, Chapter 23, this volume).

These ideas spread together with functionalist images projected by designers and architects on efficiency, rationalization, streamlining, and waste elimination in house planning, domestic technology design, and kitchen layout (J. Freeman 2004; Nickles 2002; Parr 2002). This functionalist-rationalist movement of the early twentieth century portrayed the "servantless housewife" as an efficient and scientific manager of housework, performing duly her roles as mother and spouse but also, important, as a

modern consumer of domestic technologies, industrialized and processed foods (Bijker and Bijsterveld 2000; Lupton and Miller 1996). One significant conclusion of the work by historians and sociologists of technology is that the design of domestic technologies and kitchen gadgets evolved profoundly embedded in a social and cultural context and were the result of a "dynamic process of production and consumption" (A. Clarke 1999: 56). Different social groups played an important role in the construction and design of domestic technologies and in promoting take up by end users.[14] Attempts to understand how technology impacts on society and how users take up new technologies have been the subject of science and technology studies.

THE CONTRIBUTION OF STS TO INDUSTRIAL AND FOOD TECHNOLOGY LITERATURE

Different strands of scholarship have contributed to understanding user-technology relations, especially after the mid-1980s with the development of science and technology studies (STS). This new discipline was the result of cross-fertilization among the sociology of scientific knowledge (SSK), the sociology of technology, and the history of technology and science. Different approaches have been particularly influential in depicting the relationships between persons and food technologies within an STS perspective: the social shaping of technology (MacKenzie and Wajcman 1985), the Social Construction of Technology (SCOT) (Bijker 1997; Bijker, Hughes, and Pinch 1987), and Actor-Network Theory (Callon 1986; Latour 1987; J. Law 1991). All three constructivist approaches stand against technological determinism that depicts a view of technologies as the main driver of social change, which may result in successes or failures. Contrary to this, a constructivist approach emphasizes that technological artifacts are socially and culturally embedded and subject to sociocultural meanings, and hence, open to sociological examination (Lohan 2000; Wajcman 2000).

A critique leveled at some strands of constructivist approaches is their replacement of one type of determinism (the technological) with another (the social). Yet SCOT program supporters, particularly Actor-Network Theory scholars, have striven to redress this balance. For instance, the SCOT model has popularized the concepts of *interpretative flexibility, seamless web,* and *closure.* The first concept describes the process through which relevant social groups attribute different meanings and different uses to the same artifact. Thus, the artifact is open and flexible to the unintended consequences enacted by its users (Bijker 1987; Lohan 2000: 899). The process of closure describes the stabilization of meanings and uses of the artifact, for instance, a fridge is used to store and keep food chilly (and yet closure processes are never totally closed, as it is shown by Hand and Shove 2007).

The *seamless web* concept applied by Thomas P. Hughes (1986) and then developed by Bijker, Hughes, and Pinch (1987) captures the idea that technological development is not a linear process that follows from scientific discoveries (as depicted by linear models of innovation), but instead it is a fluid process. Science, technology, and society are

understood as "constituting 'seamless webs,' or sociotechnical networks, rather than as distinct entities" (Rappert, Balmer, and Stone 2008: 722).

It is precisely the mutual constitution of technology and society that ANT adherents foreground with the concept of *symmetry.* In their view, the networks assembled to the making of technologies are heterogeneous, composed of various elements, from humans to nonhumans. This opens up the possibility for other alternative perspectives of actorship beyond intentionality (De Laet and Mol 2000: 252).

Material semiotic approaches employ the term *script* (Akrich 1992) to apprehend how technologies enable or constrain human practices. In the design phase of technologies objects are in-scripted with what it allows to do or what it denies doing. These scripts, or "scenarios," "attribute or delegate specific competences, actions, and responsibilities to users and technological artefacts" (Oudshoorn and Pinch 2007: 549). Thus, competences and agency are distributed between humans and nonhumans. The script approach resembles Woolgar's notion of user configuration (Woolgar 1991), and in fact, both perspectives are concerned with grasping how designers inscribe their intended views of the use of technology. However, the script approach gives more visibility to users. Such visibility is conceptually operationalized through the notions of "subscription" and "de-inscription," whereby users may deploy an "antiprogram" to refuse using the object according to the intended views formatted by designers.

This view gets closer to users and consumers and their sociocultural contexts of acquisition, appropriation, and domestication. There has been a long tradition in cultural studies and material culture exploring how consumers use objects and how these objects have their own biographical careers as they go through systems of commodification and de-commodification (Appadurai 1986). Domestication is a useful concept in cultural studies to describe how technologies are embedded in everyday life. Thus, they become important devices in the ordering of routines (Shove et al. 2007: 8; Silverstone and Hirsch 1992).

The field of industrial and domestic food technologies has drawn from this prolific scholarship to grasp the relationship between humans and technology. In the remainder of this chapter some of the main debates are addressed.

MAIN DEBATES IN THE FIELD OF INDUSTRIAL AND DOMESTIC FOOD TECHNOLOGIES

Gender Inequalities or Female Empowerment

The first feminist studies of technology were primarily concerned with uncovering and recovering women "hidden from history," focusing on the impacts of technology on women's lives (Wajcman 2000: 449). While these first studies were marked by a "social shaping of technology" approach taking heed of structural sociocultural divisions in society, the second wave of feminist studies of technology was influenced by a social constructivism approach. Thus, the SCOT model applied to feminist studies explored

how these patriarchal and capitalist structures were symbolically encoded in technology design and manufacture.

To illustrate, in a comprehensive case study of the life cycle of the microwave, Cockburn and Ormrod (1993) revealed that gendered meanings and hierarchies were symbolically attached to this cooker from its conception up to its use (design and development, production, marketing, and use). Following the microwave throughout its life cycle has uncovered the gendering processes enacted through a split between the world of women associated with cooking and the world of men associated with engineering and managerial activities. This study on the microwave was important to the STS literature on two fronts: it has given centrality to gender issues (traditionally STS and ANT studies are too focused on following big projects, controversies, and male heroes) and has decentered the focus on design to include all stages that follow from production up to end users. This strategy of reaching out to end users goes together with making women visible. As Wajcman explains: "Once the lens is widened to include manufacturing operatives, marketing and sales personnel, and the consumers and end-users of technologies, women's work immediately comes to view. More women are literally present, the further downstream you go from the design process" (2000: 453).

In another study that looks into the tomato industry in Canada, the United States, and Mexico, the lowest-paid and the least-skilled women also become visible as manufacturing operatives and field workers (Barndt 2008). The study unearths the inequalities and social injustice that fall upon women and ethnic minorities involved in the high-tech tomato industry. Here, working-class and indigenous women in the south (Mexico) were put in strenuous conditions (labor exploration, health-related hazards from pesticide use, racial and gender discrimination) to deliver freshness, health, and nutrition to white middle-class women in the north (United States and Canada).[15]

Feminist scholarship on industrial and domestic food technologies tends to emphasize gender inequalities by paying attention to issues of power, control, and authority in their analyses. In fact, research on the gender division of labor has enormously contributed to understanding inequalities both in food industry and households, although the latter are clearly more emphasized.

There is a long debate on the changing or prevailing structural divisions of domestic labor (Oakley 1974; Vanek 1974), and some authors call attention to their measurements problems (Warde and Hetherington 1993). This debate has consecutively shifted attention to the emotional aspects of housework, notably the caring aspects of the division of labor (De Vault 1991). Cooking and food preparation can be pleasurable tasks through which women express care and love for their families (men and children), often to the detriment of their own taste preferences (Charles and Kerr 1988; Murcott 1983b).

Contemporary feminist studies on technology offer a much more complex understanding of the relationship between gender and technology, but without leaving aside women's subordination or domination. Thus, the use of domestic technologies can be either empowering or disempowering for women (see Murcott 1983c and

Wajcman 1991). They can serve as a form of reproducing gender inequalities or as resistance to such asymmetries, both in the private sphere of the family and in the public space (e.g., refusal to feed their families with processed food). Anthropological research conducted in rural China and in South Africa also depicted gender negotiations with domestic technologies (e.g., the water pump and the coal stove) in everyday life, both helping to reproduce or challenge women's identities (Meintjes 2001; Wu 2008).[16]

Time-saving Technologies or More Work for Mother

Many advertising campaigns boast about the time-saving capacities of convenience foods, microwave ovens, and other appliances. Almost forty years ago, Joann Vanek (1974) concluded that women outside the labor market devoted as much time (if not more) to housework as the women living in the period between 1926 and 1966. A few years after Vanek's study, Ruth Schwartz-Cowan arrived at similar conclusions, wherein home mechanization has had a marginal effect in decreasing the time women devote to domestic tasks (cleaning, child care, laundry, shopping). To reiterate, standards and expected social norms of cleaning, feeding, and caring have become more demanding. But apart from rising standards, domestic technologies and industrially processed foods may reduce undertaking certain time-consuming tasks. Simultaneously, they also create other tasks (e.g., the first models of fruit juicers were cumbersome to clean). Solving this paradox—that "mechanization of the home had not substantially decreased the amount of time women spend on household tasks" (Wajcman 2000: 449)—has been the subject of much debate and many ambiguous findings (see Gershuny and Robinson 1988). A recent study by Bittman, Rice, and Wajcman concludes, however, that "owning domestic technology rarely reduces unpaid household work. Indeed, in some cases owning appliances marginally increases the time spent on the relevant task" (2004: 412).

Studies that focus on the distribution of time across activities (work, consumption, housework, and leisure) tend to use time-budget techniques to quantify the number of hours occupied in food work. Schor's work-spend equation (Schor 1992) shows that in the United States, as people work more to spend more, they spend more time on both activities, hence the feeling of being always in a rush. This is particularly felt among women facing the "second shift," as they tend to juggle paid employment with nonpaid domestic chores, having to multitask or follow a strict plan (Gershuny 1992; Thompson 1996).

Commercial manufacturing, service industries, and advertising agencies build on these ideas of time saving to produce and market domestic technologies or convenience foods (e.g., ready meals, frozen foods). As food work has not declined among women but has instead switched venues with the growing involvement of women in the low-paid commercial sector of food production and preparation, the appeal for domestic technologies and convenience foods has captured both middle- and working-class women, as both suffered from the "second shift." After a long day in the office, in the field, or in the factory, arriving home and still having to cook for their families may partly explain

the appeal domestic technologies hold for women. Domestic devices and convenience foods help to "keep on top of things" and offer a sense of control and management of personal time. Paradoxically, the very same solutions for time scarcity contribute to exacerbating further the feeling of being harried (Shove 2003; Southerton 2003). This seemingly contradictory assertion is part of a set of studies on domestic food technologies that focus on the changing temporal organization of daily practices.

Studies by Shove and Southerton (2000), Southerton (2003), Shove (2003), and Hand and Shove (2007) emphasize the importance of the relationship between technology, time, and social order. Shove and Southerton's article follows diachronically the British freezer and seeks to understand different phases for its normalization. They conclude that the freezer-microwave alliance confers a "particular form of convenience" not associated "with the saving of time but with ordering, scheduling, co-ordination and timing" (Shove and Southerton 2000: 313). Important, convenience goods and services enable fragmentation of practices into their component parts and the resequencing and reordering into ever more individualized personal schedules (Southerton 2011).

Another relevant aspect brought in by these studies that have a clear practice-based approach applied to consumption (Warde 2005) is that the freezer "helps redistribute time and labour within the household and so alleviates some of the pressures of modern life. Yet those pressures are in part a consequence of just such redistributions of time and labour" (Shove 2003: 178). In Southerton's study, domestic technologies and convenience foods were used to resequence and reorder busy times of work and domestic activities ("hot spots") to create space for quality time ("cold spots"). As everybody was using the same strategies of fragmentation, resequencing, and time shifting, creating ever more idiosyncratic personal schedules, it was increasingly difficult to coordinate personal schedules with others (Southerton 2003). It was also found that food technologies contributed to seal a compromise between care and convenience and ease some anxiety ensued from failing to care enough for others (e.g., by not cooking foods from scratch).

Decline, Revision, Reskilling, Deskilling, or Distributed Competences

Research on the effects of domestic food technologies and industrially processed foods on cooking skills has become more apparent in the last decade or so. Recent studies have greatly contributed to unpacking the perceived problem of a decline of cooking skills and the (apparent) negative impact of industrial and domestic food technologies in devaluing cooking. Researchers tried to unpack the paradox of an alleged demise of cooking skills and the popularization of TV cookery programs. People may not know how to cook with their hands, but cook with their eyes and imagination while watching TV . . . By offering a persuasive understanding of food competences and technology, social scientific research has helped to go beyond these impressionistic accounts of domestic and industrial food technology as responsible for a loss of skills (see Murcott 1997; Meah and Watson 2011). According to Short (2006), advocates of deskilling base their

arguments on a technical or task-centered approach to cooking skills, underestimating the value of the context of cooking (e.g., looking after children while cooking). Insofar as technologies should be seen in context, so are the skills and competences to use those artifacts.

In the deskilling debate, kitchen technologies and convenience foods are often blamed for the decline of cooking skills. Yet authors like Silva (2000) point out that the microwave oven often demands a more skillful cook for its operation than a traditional cooker. Moreover, technologies may open up a myriad of repertoires of know-how and skills as people practice with them, up-skilling instead of deskilling. This is observed in a study of a popular multi-food processor in Portugal (Bimby), wherein embodied/perceptual skills (e.g., hearing) were recurrently used to check if a step of a recipe was complete (Truninger 2011). Users of this technology had to learn how to identify different noises produced by Bimby (the noise of grating cheese was different from the noise of grating bread), learning new skills while practicing with the technology. An interesting aspect not explored in the study is the importance of employing sensory methods (namely audio methods or sensory ethnography (Pink 2009) to provide a better understanding of the complexity of cooking skills while doing technologically mediated food work. Anthropologists of technology have also provided fascinating studies on embodied skills and the use of domestic technologies in rural China (see the 2008 study by Flitsch on the uses of the *kang*—a cooking appliance).

Other studies take the kitchen as the unit of analysis[17] and conclude that its fabric (layout, materials, architecture) can foster or hamper what people are able to do in it or what family life images people can enact (Shove et al. 2007). In this vein, competences are seen as distributed between industrial and domestic technologies, the kitchen hardware and people. A topical and insightful study by Meah and Watson on cooking skills employed a life-course perspective to conclude aptly that: "Cooking skills are learnt, appropriated and reassessed. From multiple sources and according to shifting life circumstances, from major events of partnering, separating and parenthood, through a new TV cooking programme capturing someone somehow ready to engage anew with the challenges and pleasures of cooking" (Meah and Watson 2011: 6).

CONCLUSION: GAPS AND FUTURE RESEARCH

The preceding sections offered a critical review of the emergence and development of research on industrial and domestic food technologies. Historians of technology made important inroads to understanding the developments of industrial food technology. The first studies unpacked with great technical detail the main shifts, the key inventions, and major (male) figures of technological food development. However, the reader never quite knew what happened to failed experiences or inventions or what was the role of the "missing masses" (Latour 1994) in these technological transformations, namely the faith of other humans situated in different social positions (e.g., women, children, ethnic minorities) and also nonhumans (e.g., bacteria). Recent research on industrial food

technologies by a plethora of disciplines (anthropology, geography, sociology, economics, business, and management) has striven to correct this gap, also casting their net wider onto non-Western societies in both rural and urban areas (although more research is still welcome in this area).

If, at the beginning, there was a tendency to focus on an either/or account of the development and uptake of technologies by looking at the historical processes of invention, innovation, production, and impact, after the '80s more studies appeared emphasizing the importance of looking at the "consumption junction" (R. S. Cowan 1987). In the last decades, scholars have made a concerted effort to connect production with consumption by paying attention to the contexts of cultural intermediation (e.g., consumer organizations, women's advisory committees, home economists, food guides). Research on this topic has also benefited from the cross-fertilization between STS and sociology of consumption (notably the studies by Elizabeth Shove and colleagues on the freezer) that have helped to broaden this field. This work tapped into some of the missing elements that have not been well addressed in previous studies of technology, namely by:

1. Exploring modes of integration of consumption, technology, and practice rather than focusing on a detailed examination of single appliances (e.g., the microwave case by Cockburn and Ormrod 1993);
2. Taking more seriously the mundane, inconspicuous, and unremarkable technologies (such as the white goods normalized in many kitchens) rather than focusing on conspicuous consumption (e.g., brown goods such as TV sets, video recorders);
3. Taking heed of the environmental and ethical impacts of acquisition, appropriation, and use of industrial and domestic food technologies (e.g., energy impacts of cold chains; unfairness of labor conditions in the agro-food industry; health impacts of industrially processed foods).

On the third point, such studies were important for grasping how unsustainable systems and infrastructures, suites of industrial and domestic food technologies, and associated habits and conventions coevolve over time. How to unlock unsustainable industrial and food domestic technologies together with its practices, that move along path dependent trajectories, should be the focus of future research. This would further consolidate the findings of this recent stream of studies, some of them informed by practice theory (see Schatzki 2011 for a recent definition).

Undoubtedly, studies on industrial and domestic food technologies have contributed enormously to unveiling the reproduction of structural gender and social divisions. The contribution of feminist studies of technology was central for this endeavor. However, in that tradition there is a relative dearth of research on men/masculinities and technologies, especially in food technologies. This is surprising on two counts: the traditional hegemonic masculinity of technologies; the increasing prominence of cooking practices in shaping young men/masculine identities. Recent publications have tried

to address this gap (see, for instance, the special issue by Lohan and Faulkner on "Masculinities and Technologies," 2004), but relationships with food technologies are still under-researched. And when they are examined, there is a tendency to situate such studies among conspicuous cooking practices (celebrity chefs like Jamie Oliver) instead of looking at the more mundane and unremarkable daily food work. Moreover, the artificial separation between consumption and production has also implied a gender division of labor, wherein researchers tended to focus on men in the production sphere and on women in the domestic sphere. A more fluid account of gender performance and production-consumption connections is welcome in the future.

There is also scope for redirecting intellectual work to examine the use of food technologies in multiple sites or modes of food provisioning (domestic, industrial, commercial, state, and community). Researchers have focused their efforts in the industrial, and especially, middle-class domestic kitchens, and there is a need to understand better the use of food technology in public food services (schools, hospitals, and prisons), in community food schemes (community food/cooking training), and in commercial restaurant kitchens. Plus, more research is needed on food innovations and product reformulation in institutional and commercial kitchens, notably examining their role in alleviating or further intensifying moral panics. Going beyond the domestic kitchen onto the institutional and commercial sites of food preparation, preservation, storage, and cooking will unveil that the coevolution of food practices and of industrial and domestic food technologies is, indubitably, an instituted process of change.

NOTES

1. Whether this promise has been fulfilled or not lies outside the coverage of this chapter. See a special issue on "The Nature of Technology" at *Cambridge Journal of Economics,* 34(1) (January 2010) for more on this topic.
2. These artificial fertilizers were based on superphosphate. James Murray was the first manufacturer of this fertilizer in 1817 (Dublin). From 1834 onward John Lawes, later joined by J. H. Gilbert, established a large-scale industry. By 1870, their factory was annually producing forty thousand tons of superphosphate (Derry and Williams 1960: 553).
3. The Chinese, Indian, and Arabian cultures used snow or ice to cool drinks, fruits, and meat (Teuteberg 1995: 52).
4. A few explosions harmed workers in the pioneering canning factories (Freidberg 2009; Singer et al. 1965).
5. Developments in new preserved meats provided access to meat for deprived populations and raised its profile as a symbol for public health, nutrition, and food security. The contributions by German chemist Justus von Liebig on protein were crucial for progress in nutritional science and modern food systems (Dixon 2009; Freidberg 2009).
6. In the second half of the nineteenth century, refrigerators started to appear in the market or in fairs. James Harrison developed an ether compression machine and established an ice factory in Australia in 1851. In 1874, T. S. Mort opened the first meat-freezing factory near Sydney and a slaughterhouse the following year. Both entrepreneurs tried to ship frozen

Australian meat to Europe, but failed. The first successful shipment of frozen meat took place in 1877 between Buenos Aires and Le Havre (Singer et al. 1965; Teuteberg 1995).

7. For an historical account of the shift from corner shops, through the cooperative movement targeting deprived people to the rise of multiple retailing in Britain, see Oddy (1995).
8. Between 1985 and 1987, a survey of 100 rural households in Dingxian county shows that none had a fridge, but more than half had a TV set (Wu 2008). In urban areas, "in 1986, 65% of urban households owned a washing machine, 29% colour televisions and 18% refrigerators; by 1998 the percentages were 90.5%, 105% and 76%" (D. Davis 2005: 692, footnote 1). This urban-rural imbalance could be partly explained by China's economic reforms of the 1980s, wherein a consumer revolution started in urban areas (Flitsch 2008). Yet China's Home Appliance Subsidy Program has been an important driver for the current uptake of domestic technologies in rural areas.
9. The former ensued from the magnetron, developed by physicists in the 1920s and further improved by scientists at the University of Birmingham, and then applied to military radar equipment in the 1940s (Cockburn and Ormrod 1993); the latter originated from polyethylene (Poly-T), a plastic first synthesized at random by a German chemist in 1898 and then applied as insulation in aviation and radar sets during World War II (A. Clarke 1999).
10. The last decades of historical research on food technologies helped to trace public food scares since the mid-nineteenth century (see Atkins, Lummel, and Oddy 2007).
11. In 2005, the Japanese Ministry of Agriculture, Forestry and Fisheries launched the Basic Law of Shokuiku (Food Education) to transform the diets of the younger populations, who were replicating Western food patterns (rich in saturated fat, sugar, and salt). The law calls attention to the need to reconnect people to the traditional Japanese food culture, favoring local foods and discouraging processed and fast-food meals (see www.maff.go.jp/).
12. In a recent study on waste practices (D. Evans 2012), frozen processed foods together with the fridge-freezer-microwave complex were crucial contributors for delaying consumers' painful decisions on binning food. Thus, industrial and domestic food technologies may, at times, constitute important "moral" fixes for alleviating anxieties around food waste. This opens up an interesting debate on the construction of food anxieties and its ambiguous meanings. Yet, convenience foods connect in plural ways to debates other than anxiety; they are also sources of indulgence, pleasure, and care.
13. Home economists carved out a space of mediation between production and consumption (A. Clarke 1999; Oldenziel, de la Bruhèze, and De wit 2005). This professionalized group of home economists (including experienced lay housewives often hired by food manufacturing companies and utilities) aimed at encouraging women to take on board the ideas of scientists and medical doctors on body care and hygiene, food nutrition, and health.
14. Interesting, recent research on non-Western appropriation of domestic technologies has reached different conclusions: the appropriation of white goods in rural China has been a top-down process driven by the state with weak participation from users in the design of electrical appliances (Wu 2008). Only recently, east Asia researchers began to examine the appropriation of domestic technologies, and the findings greatly challenge the assumptions of Western STS literature, contributing to novel developments (Bray 2008). The new journal *East Asian Science, Technology and Society: An International Journal* is a good place to follow such developments.

15. Discrimination and social injustice in industry is a classical theme in social sciences. However, compelling studies on the dark history of the food industry have appeared in recent years unveiling how industrial food technologies emerged and consolidated at the cost of the physical and mental well-being of marginalized groups in society (women, children, ethnic minorities, and indigenous populations of colonial empires). See Barbara M. Tucker (1994) on agricultural workers in a war context, and Freidberg (2004) on the French beans industry.
16. For a critical review on gender and food technology transfer in developing countries, see Bourque and Warren (1987).
17. There is a rich tradition of research on kitchens by historians of science, technology, and food (see Oldenziel and Zachmann 2009 and J. Freeman 2004, among others).