

IMPACTS OF THE DOMESTIC MICROWAVE OVEN*

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Microwave ovens have been adopted by Australian households with remarkable speed. Over 5 million microwave ovens have been sold in Australia, and approximately 77 per cent of Australian homes contain one. It is plausible - but difficult to prove - that microwave ovens have reduced time spent cooking. Most foods take less time to prepare in a microwave oven than a conventional oven; women's cooking time has fallen during the microwave's diffusion period, while microwaveable foods have become widely available. The microwave oven has influenced household food purchases and can reduce household energy use via several mechanisms.

Keywords: Microwave ovens, development and diffusion, household time use, energy use, food purchases.

INTRODUCTION

Australians have been among the most enthusiastic consumers of microwave ovens, which are now common fixtures in Australian homes.¹ Household surveys show that seventy-seven per cent of Australian homes contain a microwave oven.² Given the eagerness of Australian consumers for this appliance, one would expect them to have had measurable impacts on various aspects of food-related activities. Microwave ovens are popularly believed to save time because they cook most foods faster than conventional equipment³, and energy-saving claims are made too. But are these perceptions supported by any data? If microwaves do cook faster than conventional equipment, have they made any quantifiable difference to people's behaviour? This paper examines the impacts of domestic microwave ovens on households - in terms of cooking time, food purchases, and energy use.

How do microwave ovens work?

Microwaves are a form of electromagnetic radiation characterised by wavelengths of one millimetre to one metre, and frequencies between 1 gigahertz and 1 tetrahertz (10^9 to 10^{12} cycles per second). All radiation is capable of exciting matter in some way on contact. Exposure to ultra-violet rays will damage human skin, gamma radiation induces a physical change when it acts on photographic plates, and mi-

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microwaves cause water molecules to vibrate, creating heat. Of course, it is this heat-producing characteristic of microwave radiation that makes it useful to householders as a means of preparing food. A typical modern microwave oven delivers between 500 and 800 watts of effective cooking power, about half the amount supplied at the power point. Microwave radiation is generated by a magnetron and channelled into the oven cavity, where it bounces off metal-clad walls and into the food. The microwaves make water molecules in the top few centimetres reverse polarity at around two and a half billion times per second; the resulting molecular friction produces heat, which cooks the rest of the food by conduction just as in conventional cooking.

DEVELOPMENT AND DIFFUSION

Microwave radiation was the subject of intensive military research in the 1930s, all directed at the development of radar; this work was greatly accelerated with the beginning of World War II. The discovery that microwaves could be used in the preparation of foodstuffs is attributed to Dr Percy Spencer, who is said to have observed a chocolate bar melting under microwave radiation when working on radar for Raytheon Co. In 1945 Spencer filed the first patent concerning the use of microwaves to treat food. Raytheon went on to market commercial microwave ovens in 1947, but these were unreliable, complex, cumbersome, and expensive⁴ and did not attract the attention of consumers to any significant degree. Work on the concept continued primarily with military applications in mind (for submarines, army field kitchens and aircraft) and with military sponsorship.

By the late 1950s the technology had developed sufficiently to enable its use in specific commercial applications. Ovens produced by Toshiba were installed in the restaurant cars of the Japan National Railway in 1961.⁵ Street vendors used microwave ovens to heat hot dogs and hamburgers, and they quickly became commonplace in Japanese cafeterias - albeit essentially as gimmicks to attract customers.⁶ In the USA microwaves were used for in-flight food service (heating prepared food) on domestic airlines in the early '60s.⁷

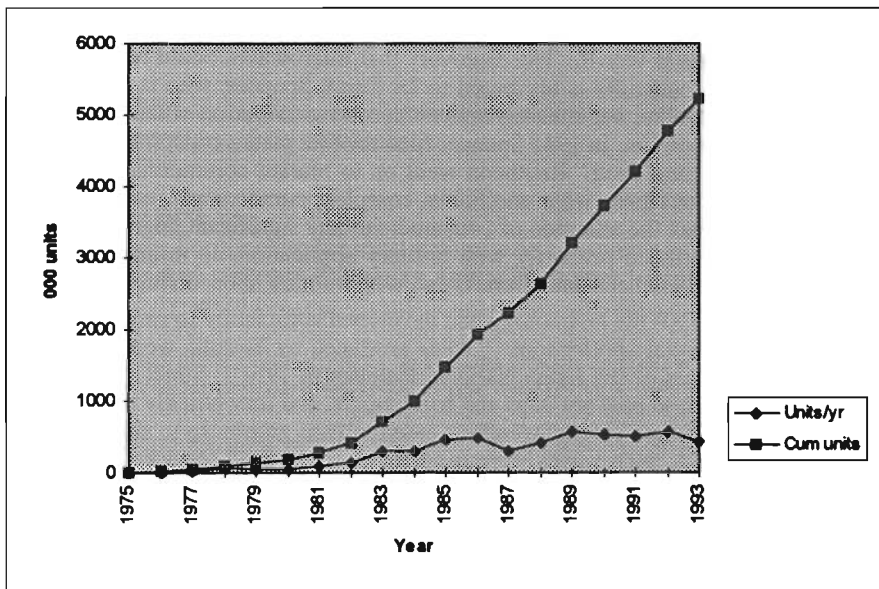
The domestic market

Japan led the way in domestic acceptance of microwave technology from 1966, following the development of a low cost, compact and reliable magnetron, and an internal power supply capable of coping with the fluctuating voltages of domestic electricity.⁸ Three hundred thousand ovens were sold in Japan in 1969. Between 1974 and 1977 Japanese consumers bought between one and one and a half million microwave ovens each year, and household saturation reached an estimated twenty-five per cent.⁹ The United States lagged slightly behind Japan in adopting the microwave oven. Sales reached 250,000 by 1972; by 1977 the figure had leapt to 2.8 million, and it was estimated that more than twelve per cent of US households possessed a microwave in 1978, by which time there were thirty-five brands and more than two hundred models available.¹⁰

Microwave ovens were first imported to Australia in 1969 and for several years

used mainly in cafeterias and take-away food outlets. But by the mid-1970s householders were buying them in substantial numbers, and by 1980 approximately 150,000 Australian households - 3 per cent - possessed a microwave oven. Diffusion was rapid throughout the '80s, household penetration reaching fifty per cent in 1989, and between 1989 and 1991 around half a million units per year were sold to domestic customers.¹¹ As already noted, it is estimated that 77.2 per cent of Australian households possessed a microwave oven by December 1995. Figure 1 shows the numbers of microwave ovens imported into Australia households since 1975, most of which were purchased and used by households.

Figure 1
Microwave oven imports, Australia: 1975–1993



Source: Australian Bureau of Statistics (1978–1994).¹²

Over five million ovens had been imported to Australia by 1993, the majority from Japan; their total import value in unadjusted Australian dollars was \$1037 million.¹³

The innovation process

In many respects the rise of the microwave as a domestic appliance follows the pattern set by other familiar items of household equipment. Wajcman¹⁴ argued that domestic technology is frequently developed or marketed as an offshoot from com-

mercial/industrial or military research (described by Wajcman as the *commercial afterthought* model), and is therefore not necessarily suitable for household applications. However, the microwave oven's place in domestic kitchens was foreseen at an early stage by Japanese manufacturers and made the subject of considerable research and development before achieving commercial success. In contrast, the microwave oven has largely failed to fulfil its intended role in industrial food processing.¹⁵ By far the most successful application of microwave technology has been in domestic food preparation.

MICROWAVE OVENS AND HOUSEHOLD WORK

Microwave ovens are generally perceived as allowing less time to be spent on meal preparation than would be required using conventional cooking methods. There is some indirect evidence that microwaves save cooking time, but a dearth of conclusive information.

Time use

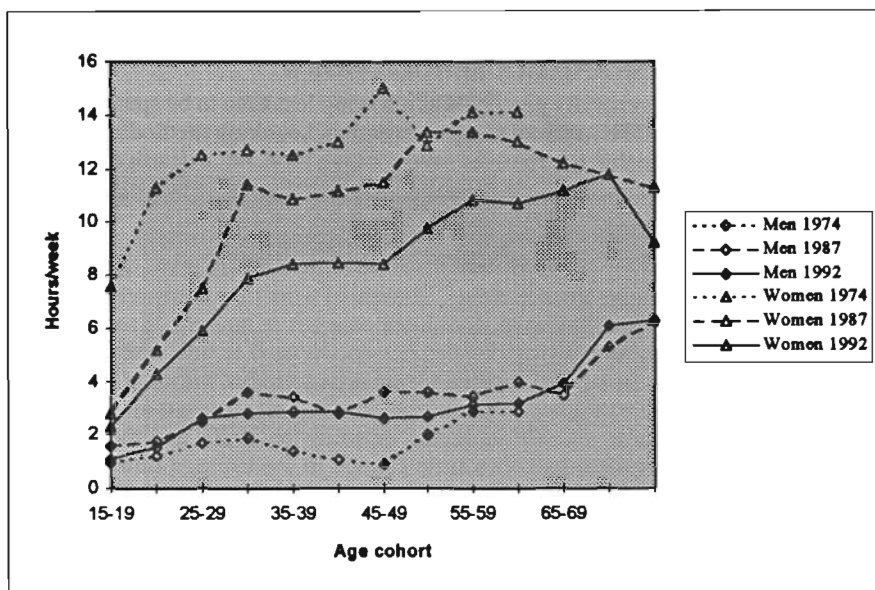
Several authors have suggested that average household work time has barely changed during the twentieth century despite significant changes in household technology. The advent of some labour-saving devices has encouraged an increase in output rather than a decrease in labour, vacuum cleaners and clothes washing machines being perhaps the best examples.¹⁶ Despite increasing mechanisation, American housewives' laundry time actually increased between the 1920s and the 1960s.¹⁷ Overall it appears that there has been little change in the average time spent on housework since early this century.¹⁸ Are microwaves bucking the trend?

In theory, microwave ovens are capable of reducing the time required for meal preparation and cleaning up through several mechanisms. The most obvious is that many foodstuffs can be cooked faster in a microwave than by conventional means. Howat et al¹⁹ found a microwave oven could cook a roast in less than half the time needed by a conventional electric range, while Samuel and Lovingood²⁰ reported average time savings of 29 per cent over thirteen foods. Many foodstuffs are now available which are processed and packaged specifically to enable rapid final preparation or re-heating in a microwave oven, which amounts to a significant relocation of work time from the household to the market. Because microwaves are particularly good at heating pre-cooked food, greater volumes of original meals can be produced and stored for consumption at a later date, thereby taking advantage of economies of scale in cooking time.²¹ Finally, dishes used to store or prepare food may also be used as cooking vessels, and food stored on crockery can be re-heated and eaten directly from the same items, in both instances saving clean-up time.

Whether the time savings achievable through the mechanisms described above are actually occurring in Australian homes is difficult to assess. The greater speed of microwave cooking undoubtedly gives cooks greater convenience and flexibility. However, in general conventional ovens need as little attention while operating as do microwaves, so longer cooking times may simply mean that meal preparation is commenced earlier and other household tasks are performed in the interim. Under

this scenario no time saving results from the use of a microwave oven. The only definitive way to measure time savings is via analysis of time use data for households with and without microwave ovens, but to the authors' knowledge no such information exists.

Figure 2
Changes in time spent in cooking by men and women, Australia: 1974, 1987 and 1992



Source: Bittman (1995), p.47.

Longitudinal changes in cooking time

We can draw some inferences about their influence by comparing trends in household cooking time with the diffusion patterns of microwave ovens and microwaveable convenience foods. As already described, Australian households have been enthusiastically purchasing microwave ovens since the early 1970s and today approximately three-quarters of households possess one. Figure 1 gives the impression that the diffusion process is continuing; a recent household survey²² found that 6.3 per cent of Australian households had bought a new microwave oven in the past twelve months, and 4.6 per cent intended to do so in the coming year. (The proportion of ovens purchased as replacements is unknown, but there is no reason to suppose it is 100 per cent.) There is a plausible link between the microwave's diffusion period and changes in cooking time. Over nearly the same period as the microwave has been available to Australian consumers, women's time spent in cooking has significantly decreased, by over 3.5 hours per week for women aged 30 to

34 and 50 to 54 years²³. Men's time appears to have increased in the period 1974-1987, but is essentially static thereafter. Figure 2 shows Australian men's and women's cooking times across five-year age cohorts for 1974, 1987 and 1992.

The role of the microwave oven in these domestic phenomena is subject to conjecture but can be posited in two ways. As women still do most of the cooking in Australian households, the obvious conclusion is that women are using microwaves and microwave-specific foods to increase their efficiency in cooking and meal-related activities and thereby save time. The other possibility is that, despite no major increase in cooking time (certainly much less than the corresponding reduction for women), men may actually be engaging in more meal production through time-efficient use of microwave ovens and readily microwaveable foods. If men are increasingly using microwave ovens to prepare meals, then women are able to reduce their own time spent in meal preparation.

Of course, factors other than technological change are implicated in the decrease in women's cooking time. Expenditure on take-way and restaurant meals has risen significantly in the past two decades²⁴, and the number of such meals eaten is also increasing. This trend is associated with greater involvement of women in the paid workforce, which may also be linked to the rise of the microwave oven. "Working wives" in the United States are significantly more likely to own microwave ovens than their non-market-employed counterparts and they also purchase meals from market sources more frequently.²⁵ The case is yet to be proven, but it is plausible that microwaves have contributed to the reduction in women's meal preparation time observed in recent decades.

Meal preparation as household work

Having outlined some changes in cooking time over the past twenty years, it is instructive to look at how time is spent in meal preparation today. Despite the decreases in women's mean cooking time described earlier, tasks associated with meals still consume more time than any other type of household work. Table 1 shows the time Australians spent in meal preparation, service and clean up activities in 1992.

Table 1.

Time spent in meal preparation and clean-up, domestic activities and total unpaid household work, minutes per day, Australia 1992.

	Preparation and service	Setting and clearing table	Clean up	Total food prep., clean up	Total domestic activities†	Total unpaid household work
Women 15+	48	1	21	71	187	317
Men 15+	15	0	8	23	101	175
Mean/adult	32	1	15	48	144	248

* Some rows do not total correctly due to rounding.

† 'Domestic activities' includes laundry, cleaning, gardening, home maintenance, transportation ...

Sources: ABS (1994)²⁶ and ABS (1993).²⁷

Australian adults spent an average of thirty-two minutes per day preparing and serving meals in 1992 and a further fifteen minutes per day cleaning up afterwards. These amounts represent approximately thirty-three per cent of time spent performing domestic activities and nineteen per cent of total unpaid work time. Clearly the work done to provide meals for households is extremely valuable, and therefore any time freed by the use of a microwave oven is equally important.

FOOD AND TIME

According to Ironmonger²⁸, change in the technology of household production operates in two ways - through changes in the characteristics of the commodities transformed by the household into final goods and services, and through changes in the characteristics of the equipment used by households. Microwave ovens clearly represent a significant change in domestic technology, and their effect on the types of foods purchased by households is also important. Although they are capable of being used much like conventional ovens for producing complex meals, and the latest programmable models offer a broad array of cooking options, microwave ovens are primarily used to re-heat cooked food, defrost frozen food items and for preparing convenience foods.²⁹ The use of convenience foods - in particular foods designed, processed and packaged specifically for microwave ovens - is perhaps the most plausible means by which microwaves may save cooking time.

Microwaveable food products

In 1988 American companies released 8183 new food products onto the market, and 962 (nearly 12 per cent) were specifically designed for microwaving³⁰, a large increase over the 278 released in 1986.³¹ Although by 1993 the number of new microwaveable items on the US market had fallen slightly³² it is clear that significant demand for such products continues. In Australia there was a strong shift on the part of consumers away from raw foods and towards convenience foods in the 1980s.³³ As mentioned earlier, pre-packaged foods represent a substitution of market labour for that of the household, and undoubtedly mean a further saving of cooking (re-heating) time in actual use - after all, that is the *raison d'être* of such foods. In conjunction with increasing expenditure on restaurant and take-away food, rising purchases of convenience foods may signal changing perceptions of the social and family significance of home-prepared meals as well as new ideas about nutrition.³⁴

Quality of microwaved food

At times claims have surfaced, sometimes in the public domain, that microwaves pose health risks by dangerously altering food or via incomplete heating. Reports that microwaving babies' bottles caused dangerous toxins to develop were based upon medical experiments in which milk was heated for long periods and to high temperatures, quite unlike actual conditions of use.³⁵ Concerns about the nutritional content of microwaved food are misplaced - there is evidence that microwaves destroy vitamins to a lesser degree than conventional heat.³⁶ Problems with

food-borne organisms remaining viable in microwaved food are mostly the result of lack of knowledge about microwave cooking techniques,³⁷ and can just as easily occur with non-microwaved food.

Another perceived disadvantage of microwave ovens is that their product often lacks taste and texture. For example, they are popularly believed to be unsuitable for cooking meat, but blind tasting sessions contrasting microwaved and conventionally cooked meat have not verified that perception.³⁸ The general lack of microwave cooking knowledge among consumers may be responsible for poor results. If time savings and ease of use are motivations for microwave oven buyers, then it makes sense that consumers are reticent about investing time in learning microwave cookery, even though they may be unhappy with the fruits of their labours.

ENERGY CONSUMPTION

The second major advantage claimed for the microwave oven is that it is an energy-efficient cooking appliance. Despite achieving less than 50 per cent efficiency in converting electricity to microwave energy, microwaves direct almost all their useful energy into cooking food - little is wasted on heating the appliance or the container as happens with conventional cooking methods. Many studies have compared the energy required by microwave ovens and conventional electric ovens; most have found that microwaves are more efficient although reports of the energy performance gaps vary widely. On the other hand, comparisons of microwaves and electric stove elements show the latter to be more efficient.³⁹

The nature of the food is a strong influence on energy requirements. Korschgen and Baldwin⁴⁰ achieved energy savings of between 25 and 35 per cent when cooking beef roasts in a microwave. Samuel and Lovingood⁴¹ found that a microwave/convection oven used 22.5 per cent less energy than a conventional electric oven to cook a beef rib roast, 48.2 per cent less for chicken, and 22.9 per cent less over all foods tested. Richardson et al⁴² compared energy performance for forty-one convenience and home-prepared foods, and found that about two-thirds required more energy to cook by conventional means. For foods needing more conventional energy, microwave cooking saved 60.9 per cent; in the reverse case, cooking on stove-top elements saved 33.7 per cent; overall, Richardson et al's microwave oven triumphed by 47.6 per cent.

Clearly microwaves offer reductions in energy consumption - and therefore cost and environmental impact - when replacing cooking done in an electric oven, but not in comparison to cooking food on a stove element. This is an important point when it is considered that microwaves are principally used for re-heating and defrosting, tasks which can often be performed on a stove-top element, depending on the food in question. There are a number of ways in which microwave ovens can save energy indirectly. Cooking or reheating with a microwave rather than a conventional oven generates fewer dirty dishes and therefore less washing-up, and domestic hot water is extremely energy-intensive. As already noted, many microwave-specific foods have already been cooked to some extent by the manufacturer,

and industrial cooking processes are considerably more efficient due to economies of scale, thus reducing overall energy consumption as well as the household's energy use.

Energy use and environmental impact

The comparative studies cited above measured energy consumption at the appliance, or *end-use* energy. This is a meaningful measurement for the consumer who pays for energy actually consumed but does not reflect *primary* energy use and hence environmental impact. Primary energy consumed by an electric appliance is invariably greater than that used by a similar gas-powered item, because electricity is a secondary energy form and suffers large losses in conversion from its primary state and in transmission.⁴³ About four kilowatts of primary energy (stored as fossil fuel) are needed to deliver one kilowatt of electricity to an Australian customer; the resulting greenhouse gas emissions are correspondingly higher than those associated with energy from natural gas. Unless a microwave oven can accomplish a cooking task with around a quarter as much energy as a gas oven, it will consume more primary energy and generate more greenhouse gas.

SUMMARY

In just over twenty-five years Australian consumers have embraced the microwave oven to the extent that we now support one of the highest ownership rates in the world. This has occurred despite the lack of conclusive evidence of their efficacy as time and energy savers in actual use. However, arguments for microwave ovens having had an impact on various household processes can be made on several fronts, and they have had a definite influence on the nature of household food purchases. Microwave ovens remain an interesting example of a technology which has leaped from a relatively obscure technical niche into everyday household use.

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