Resource Reallocation and Productivity Growth in the Australian Dairy Industry: Implications of Deregulation

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Executive Summary

This paper uses farm-level data to examine resource reallocation in the Australian dairy industry between 1979 and 2013, and assesses the contribution of this process to industry-level productivity growth before and after deregulation reforms were introduced in 2000. We show that deregulation facilitated the reallocation of resources from less efficient farms to more efficient ones, helping to offset the effects of a slowdown in within-farm technological progress on overall productivity growth. Moreover, resource reallocation following the reform mainly involved the movement of resources between farms that use different production systems in different regions, and which therefore have inherently different productivity performance. Further gains in aggregate productivity are likely to be derived mainly from movements of resources among farms that use similar production systems.
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1 Introduction

The dairy industry is one of the most important rural industries in Australia, ranked third behind the crop and livestock industries. Over the past three and a half decades there has been significant structural change in the industry. Between 1979 and 2013, total output increased by 24 per cent while the total number of dairy farms fell by 66 per cent (from 20,951 to 7,086) and the dairy herd declined by 12 per cent (from 1.9 to 1.7 million head) (ABARES 2015). Reflecting these changes, average farm size (measured in terms of real output value) has more than doubled over this period and a greater share of total output is now produced by fewer, larger farms.

Rapid structural change in the Australian dairy industry has triggered the movement of resources between farms and thereby contributed to ongoing growth in aggregate productivity. Industry-level total factor productivity (TFP) increased by 1.7 per cent a year on average between 1979 and 2013, significantly higher than TFP growth in the broadacre industry (1.1 per cent a year). Growth in productivity has been robust in the Australian dairy industry, continuing in recent years despite repeated droughts and ongoing declines in the terms of trade.

The introduction of market-oriented deregulation reforms in the Australian dairy industry are expected to have contributed to industry-level productivity growth (Edwards 2003). In 2000, the Australian government started to reform the dairy industry by abolishing state-level marketing arrangements and removing other regulations. This policy reform was expected to materially enhance production efficiency on dairy farms but empirical evidence in the literature is inconclusive and some results conflict with this expectation. For an instance, Kompas and Che (2004, 2006) found that average farm-level productivity growth slowed after 2000 compared with the 1980s and the 1990s. Similarly, Balcombe et al. (2006) found that only dairy farms in New South Wales and Victoria achieved higher technological efficiency following deregulation, and that these gains were modest.

A shortcoming of previous studies is that they have sought to assess the impact of deregulation by focusing on technological progress or efficiency improvements within dairy farms. However, while deregulation may have an impact on the productivity of individual farms, it is more likely to affect farmers’ decisions about entering and exiting the industry and the size of their operations, and will thereby contribute to industry-level productivity growth through the dynamics generated by structural adjustment and the resource reallocation between farms that this induces (Harris 2004). In particular, as market price distortions are removed, resources are likely to move from less efficient to more efficient farms raising the market share of the latter,
which in turn will lift industry-level productivity even if there is no change in productivity of individual farms.

This paper uses an unbalanced panel dataset from ABARES’ Australian Dairy Industry Survey (ADIS) to examine the impact of deregulating the milk market on industry-level productivity growth. Specifically, we distinguish industry-level TFP growth attributable to technological progress within farms from the growth generated by resource reallocation between farms. We measure the impact of the deregulation reforms through these two drivers of productivity growth by comparing the pre- and post-reform periods in different regions. The results show the reforms contributed to industry-level productivity growth not only by raising average within-farm technology progress but also through the exit of relatively inefficient farms in some states, and by shifting resources between farms operating different production systems with inherent productivity differences. Further improvements in industry-level productivity are likely to result mainly from the reallocation of resources between farms within each production system.

To our knowledge, this is the first study that empirically examines the economic impact of deregulation in the Australian dairy industry through analysing the complex relationship between resource reallocation and industry-level productivity growth. In particular, we have attempted to draw implications for industry-level productivity growth of resource reallocation between farms that use two different production systems (seasonal and year-round). This provides a better understanding of the mechanism underlying the effects of deregulation, and provides useful insights for policy makers seeking to further improve industry-level productivity.

The remainder of the paper is organised as follows. Section 2 provides a brief description of the deregulation reforms and their likely impact on the dairy industry. Section 3 outlines the model used to decompose industry-level productivity growth into within farm technological progress and resource reallocation. Section 4 describes the dataset and the variables used in the analysis. Section 5 discusses the results, specifically the impact of deregulation on industry-level productivity and the contribution of within and between-farm effects. Sensitivity analysis is presented in Section 6 and Section 7 concludes.
Deregulation Reforms in the Australian Dairy Industry

The Australian dairy industry is the third largest sector in agriculture. In 2013 it produced more than 9.2 billion litres of milk which was worth around A$ 4 billion at the farm gate. Around 40,000 workers are directly employed on dairy farms and another 60,000 are employed in dairy-related businesses in downstream sectors such as manufacturing, transport and distribution. This industry is also export-oriented, with nearly half of total output exported, accounting for around 10 per cent of global milk exports (ABARES 2015). The industry is comprised of farms that use heterogeneous production technologies depending on factors such as location, climate conditions and markets (Productivity Commission 2001). Dairy farming relies on the availability of relatively abundant water and hence the majority of Australian dairy farms are located in high-rainfall coastal zones, although a substantial number of irrigated dairy farms also operate in the Murray-Darling Basin (Figure 1). Unlike other sectors, until the 2000s this industry was the subject of significant government interventions that sought to boost exports and support farmers.

Figure 1 Geographical Distribution of Dairy Farms in Australia

Source: ABARES ADIS Survey.

Historically, the dairy industry in Australia was highly assisted and regulated by both state and Commonwealth governments. According to the Productivity Commission (2001) the effective
rate of industry assistance in 2000 was 51 per cent, 8 and half times greater than the rate of assistance for the agriculture industry as a whole (6 per cent). This high rate of assistance was largely achieved through two policy instruments: statutory marketing authorities (SMAs) and the domestic market support (DMS) scheme. SMAs were created by state governments to regulate marketing of milk between states, while the DMS was administered by the Commonwealth government to subsidise the export of manufacturing milk.

SMAs were responsible for issuing licenses to milk-producers, overseeing milk quality and regulating the trade of milk between states. These agencies were able to set farm gate prices of milk for final products (such as fresh milk and manufactured milk products) and, through their interventions in domestic markets, were able to set different prices for different kinds of milk. For example, farm gate prices for fresh milk (also known as ‘market’ milk) were usually much higher than the prices of manufactured milk.

Two systems were used to manage the different milk markets in each state: a system known as ‘equitable marketing’ was used in Victoria, Tasmania and South Australia to allocate the price premium for market milk across all farmers. Market milk accounted for a relatively small proportion of total production in these states. In contrast, market milk quotas, which were attached to individual parcels of land, were used to determine which farms produced market milk in Queensland, New South Wales and Western Australia, where this kind of milk accounted for a greater share of total output.

The DMS arrangement was established in 1986 as an ‘industry-funded’ instrument aimed to support milk exports at the Commonwealth level. Under this arrangement, a levy (tax) was imposed on farmers operating under the two systems and the proceeds were then distributed to farmers to subsidise export of manufactured dairy products. However, the subsidy had a flow-on effect on the domestic market – the levy was largely passed on to domestic consumers of fresh milk and manufactured dairy products. In addition, because some states exported a greater proportion of milk than others, the DMS also generated levy transfers between states.

These interventions allowed state and Commonwealth governments to control the domestic production and marketing of milk in Australia throughout the 1980s and the 1990s. As a consequence, Australia had, in reality, six separate dairy industries (one in each state) and within each state, there was an artificial segregation between manufactured and fresh milk.

The main impact of these regulations was to curtail market competition and create significant differences between the prices of manufacturing and fresh milk, with domestic consumers having to pay higher prices. The lack of market competition also distorted demand and supply
with dairy farms in some regions being overpaid and the milk market oversupplied (Sieper 1982, Edwards 2003).

Furthermore, the high price premium also became an issue when free trade agreements were signed between Australia and its trade partners. For example, the regulation-induced higher domestic price made the Australian market unduly attractive to milk producers in other countries (in particular, New Zealand), resulting in more dairy products entering Australia than would have occurred if the market were not subject to these distortions (Edwards 2003). In addition, the regulation also hindered innovation in milk transporting and marketing. For example, the use of milk treated at ultra-high temperatures to extend shelf-life was retarded by the policy of selling milk to processors at prices in excess of those for manufactured milk (CIE 1999).

Deregulation of the dairy market occurred on 1 July 2000. This reform involved the abolition of longstanding institutions, namely the SMAs in each state and ending the segregation of markets for manufactured and fresh milk. At almost the same time, the DMS scheme for supporting exports of manufacturing milk was phased out on 30 June 2000. As a consequence of deregulation, there was a strong tendency for the prices of all types of milk to be pulled towards the international price, namely the export price of manufactured milk. The market milk price in Australia immediately dropped by around 22 cents per litre and has since gradually increased in line with international market prices (PWC 2015) (Figure 2).

**Figure 2 Impact of deregulation on Australian milk prices**

Deregulation helped create a single milk market in Australia, and it placed significant pressure on dairy farms in some states, particularly those with quotas for the production of market milk. Between 2000 and 2013, the national dairy herd declined by 23 per cent, from 2.2 million head to 1.7 million head, in contrast to the increasing trend which prevailed in the 1990s. Over the same period, milk yield per cow continued to increase, from 4996 litres per cow in 2000 to 5467 litres per cow in 2013. A number of empirical studies have been undertaken to assess the economic impact of deregulation on the dairy industry. However, existing studies have failed to find a significant improvement in farm productivity following deregulation (Kompas and Che 2006). One reason for this is that previous studies have focussed on efficiency improvements within dairy farms, which does not necessarily capture the effects of this reform on the structure of the dairy industry, and hence its contribution to industry-level productivity growth.

In this paper, we examine the impact of deregulation on industry-level productivity by analysing resource reallocation between farms, with a particular focus on farms using different production systems across regions. In particular, Australian dairy farmers use either seasonal or year round production systems, depending on local factors such as climate conditions, market requirements and the cost of inputs (PWC 2015). In the year-round production system, calving and milk production are spread evenly throughout the year. This system is mainly used by farms close to domestic markets for fresh milk and is dominant in New South Wales, Queensland and Western Australia. In the seasonal production system, around half of the farms calve and milk during the peak period of pasture availability each year with the rest operating continuously throughout most of the year. This system is dominant in Tasmania, Victoria and South Australia. These two systems respond differently as the structure of the industry changes.
3 Resource Reallocation between Production Systems: A Decomposition Method

In this paper, resource reallocation refers to the movement of inputs between farms and the changes in output market share that this causes. In the presence of market competition, resources tend to move from less efficient farms to relatively more efficient ones, resembling a process of 'creative destruction'. As such, resource reallocation is an important source of productivity growth at the industry level of aggregation. This section provides a brief description of the methodology and estimation strategy used in this paper to examine the reallocation of resources between dairy farms in Australia.

In theory, a change in industry-level productivity can be decomposed into contributions from within-firm productivity growth and between-firm resource reallocation. These decompositions generally use one of three methods: the BHC (Baily et al. 1992), OP (Olley and Pakes 1996) and PWR (Petrin et al. 2011). Each of these approaches is based on different aggregation methods and can be used to examine different aspects of resource allocation (Sheng et al. 2015). For example, the BHC method (Baily et al. 1992, Griliches and Regev 1995, Foster et al. 2001, Petrin and Levinsohn 2005) uses fixed terms as weights when aggregating firm-level productivity, whereas the OP method (Olley and Pakes 1996, Melitz and Polanec 2012) uses distributional moments as weights. As a consequence, the BHC method is more appropriate for measuring high-frequency (or short term) changes in resource reallocation while the OP method is suitable for low-frequency (or long term) changes. In contrast, the PWR method (Petrin et al. 2011) constructs weights using more detailed data on inputs to production, and thereby seeks to identify the role of particular inputs in resource reallocation.

In this paper, we have chosen to use an extended version of the OP method to examine resource reallocation between and within groups of firms that use different production systems. We have opted for the OP method because long-term effects of deregulation at the aggregate level are more interesting and relevant for policy makers. Also, the data used in this analysis are drawn from a survey rather than a census, which limits the extent to which we can accurately identify the impact of farm entry and exit on resource reallocation, something which is an important requirement of the BHC method.

To further explain how the adjusted OP approach is used to analyse resource relocation, we start by defining aggregate productivity in the Australian dairy industry at period $t$ ($\Pi_t$) as a weighted sum of farm-level productivity:
Resource Reallocation and Productivity Growth in the Dairy Industry

\[ \Pi_t = \sum_{i \in \Omega_t} s_{it} \pi_{it} \]  

(1)

where \( s_{it} \) denotes the share of farm \( i \) in the industry at time period \( t \) (i.e. revenue or cost shares) and \( \pi_{it} \) denotes the measure of farm total factor productivity. \( \Omega_t \) represents the set of all farms in the same period. Following Olley and Pakes (1996), industry level productivity (as is shown in Equation (1)) can be represented by two components.

\[ \Pi_t = \bar{\pi}_t + \sum_{i \in \Omega_t} (s_{it} - \bar{s}_t)(\pi_{it} - \bar{\pi}_t) = \bar{\pi}_t + \text{cov}_t \]  

(2)

where \( \bar{\pi}_t = \frac{1}{N} \sum_{i=1}^{N} \pi_{it} \) is the unweighted mean of farm-level productivity and \( \bar{s}_t = \frac{1}{N} \sum_{i=1}^{N} s_{it} \) is the average share of farm \( i \) in the industry. The second component (\( \text{cov}_t \)) reflects the responsiveness of relative size of individual farms to their relative productivity differences.

Taking the first difference on both sides of Equation (2) yields the following expression for the change in industry-level productivity:

\[ \Delta \Pi_t = \Delta \bar{\pi}_t + \Delta \text{cov}_t \]  

(3)

In Equation (3), the change in industry-level productivity consists of two components: the contribution of within-farm productivity improvements (\( \Delta \bar{\pi}_t \)) and the contribution of resource reallocation between farms (\( \Delta \text{cov}_t \)) as a result of change in the size of the farms due to productivity change.

While this decomposition (through \( \Delta \text{cov}_t \)) provides a useful indication of total contribution of resource reallocation between dairy farms to aggregate productivity growth, it does not show how resource reallocation occurred between farms in different production systems. Collard-Wexler and De Locker (2013), following Melitz and Polanec (2012), extended the OP method to distinguish resource reallocation between and within groups of firms. The core idea is to use differences in the distributions of productivity moments (or weights) between the groups to identify the direction that resources move when technological progress generates idiosyncratic productivity shocks (Forster et al. 2008).

When using this approach to analyse resource reallocation between dairy farms in Australia, we need to split the total sample into at least two different types of farms. In our case, dairy farms can be divided into two groups which used the seasonal or year-round production systems. The farms can also be categorised into six groups by state of location. This grouping is analytically meaningful because there was significant market segregation between states in the pre-reform period.

As a first step, the decomposition described by Equations (2) and (3) is applied to each group of farms. It would disentangle the contribution of resource reallocation to aggregate productivity
growth from individual farms no matter which production system they adopt. This reallocation of resources between farms within each group is known as ‘within-effects’, and can be derived as in the following decomposition:

\[ \Pi_t(\phi) = \bar{\Pi}_t(\phi) + \sum_{i \in \Omega_\phi} [\bar{s}_i t - \bar{s}_i(\phi)][\bar{\pi}_i t - \bar{\pi}_i(\phi)] = \bar{\Pi}_t(\phi) + \text{cov}_t(\phi) \]  

(4)

where \( \bar{\Pi}_t(\phi) \) denotes the average productivity of a group of farms using a particular production system (\( \phi \)), and \( \bar{s}_i(\phi) \) denotes the average revenue/cost share of farms within this group. This ‘within-effects’ (\( \Pi_t(\phi) \)) captures the change in productivity caused by group-specific effects, such as technological progress and the reallocation of resources between farms in each group.

Moreover, when we treat each group of farms as a combined production unit, resource reallocation effects between groups can be measured by allowing interaction between the change in relative revenue/cost shares and relative productivity at the group level, as follows:

\[ \Pi_t = \bar{\Pi}_t(\phi) + \text{cov}_t[\bar{s}_i(\phi), \pi_t(\phi)] \]  

(5)

Equation (5) suggests that industry level productivity can be represented by the unweighted average productivity of \( M \) groups (\( \bar{\Pi}_t(\phi) = \frac{1}{M} \sum_{j \in \Omega_\phi} \Pi_t(\phi) \)) and a covariance term which measures the extent to which resources have been reallocated between groups. This resource reallocation between groups of firms is called ‘between-effects’ (Melitz and Polanec 2012).

In this paper we use Equations (4) and (5) to measure the ‘within effect’ of resource reallocation between dairy farms in each group (defined by production system or state) and ‘between-effects’ across groups. In addition, taking the first difference on both sides of these two equations reveals the contribution of each effect on industry-level productivity growth. Analysis of both the level and change in resource reallocation before and after the deregulation reforms of the 2000s provides insight into the productivity effects brought about by this policy change.
4 Data Source and Variable Definition

The data used in this study are sourced from ADIS, which ABARES has conducted annually since 1979. Farms participating in this survey provide comprehensive physical and financial information about their businesses. The sample is drawn from the business register used by the Australian Bureau of Statistics (ABS) to run the Agricultural Census. The survey provides a unique dataset which has been used by ABARES to estimate farm-level and aggregate productivity, and for broader economic research into the dairy industry.

Samples in this study consist of businesses engaged in ‘dairy cattle farming’ consistent with class 0160 in the Australian and New Zealand Standard Industrial Classification (ANZSIC). To be assigned to this ANZSIC class, farms must have an estimated annual value of agricultural operations greater than or equal to A$ 40,000 and receive more than 50 percent of their total output value from the production of milk and other dairy products.

In ADIS, the population of farms is stratified according to farm size and region and weights are designed to ensure a broad representation of all dairy farms across Australia. Data collected from each sample farm are then weighted to produce population-level estimates. Broadly speaking, weights are designed in a way that key economic indicators, such as number of farms, area of crops and number of livestock, are consistent with the regional level estimates produced by the ABS and/or from other sources which are considered reliable (Bardsley and Chambers 1984).

Using data from ADIS, we obtain an unbalanced panel dataset of dairy farms between 1979 and 2013. After removing outliers, the dataset contains 10,726 observations, ranging from 277 to 402 observations a year. Using the sample weights, this dataset represents a population of 20,951 farms in 1979 to 7,086 farms in 2013. Moreover, approximately 47 per cent of farms are represented in the survey for each two consecutive years, and more than 92 per cent of farms in the sample have been observed for at least two years. As such, the dataset is suitable for analysis both across farms and over time.

Table 1 provides summary annual statistics on the dairy industry. Between 1979 and 2013, gross output value (in terms of both milk and total output production) has increased over the

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The threshold for inclusion in the ABARES farm survey program has changed over time (ABARES 2011). The current threshold for inclusion in the survey has been used since 1994. Between 1983 and 1994 the threshold was $20,000-22,500, and from 1979 to 1983 it was $5,000.
past thirty-five years while the number of dairy farms has declined, particularly after deregulation in 2000.

**Table 1 Descriptive statistics of dairy farms in Australia: 1979 to 2013**

<table>
<thead>
<tr>
<th>Year</th>
<th>Dairy farm Population sample</th>
<th>Dairy Cows ('000)</th>
<th>Gross Value of Production (A$ m)</th>
<th>Milk Val. (A$ m)</th>
<th>Milk yield (L/cow)</th>
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<td>20951 301</td>
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To examine the effects of resource reallocation on industry-level productivity, we first derive the TFP of dairy farms and their market share using the index number method described by Zhao et al. (2012). Briefly, we use the gross output approach and aggregate 12 outputs (categorised into three groups: crop, livestock and other agricultural products) into an output quantity index, and aggregate 28 inputs (categorised into four groups: land, capital, labour and intermediate inputs) into an input quantity index. This is done for each farm in each year, with the prices or value shares of outputs and inputs used as weights.

To account for possible differences in the production technologies used by different dairy farms, and therefore differences in the relationship between outputs and inputs, a Fisher quantity index is used for the aggregation of outputs and inputs for each farm. In addition, the EKS procedure (Elteťő and Köves 1964, Szulc 1964) has been employed to ensure transitivity and consistency in the comparison between individual farms. Finally, the farm-level TFP index is defined as the output index divided by the input index.

The market shares of dairy farms are defined as the value of real output for each farm divided by the real value of industry output in the same year. Real output values are obtained by deflating nominal gross output values with a farm-level output price index, which is also calculated using a Fisher index.

Finally, to understand how resource reallocation between farms was changed following deregulation, we split the sample into two groups, namely those primarily using the seasonal production system (the farms in New South Wales, Queensland and Western Australia), and those primarily using the year-round production system (farms in Victoria, South Australia and Tasmania). In addition, the sample is further split into individual states, since milk markets were formerly controlled by individual state government agencies. This treatment allows us to decompose resource reallocation into ‘between-effects’ and ‘within-effects’ according to production system and market.

Source: ABARES estimates based on the ADIS surveys.

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<td>2009</td>
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<td>307</td>
<td>1596</td>
<td>4386.8</td>
</tr>
<tr>
<td>2010</td>
<td>7514</td>
<td>303</td>
<td>1604</td>
<td>3663.0</td>
<td>3322.2</td>
<td>5675</td>
<td>2011</td>
<td>7501</td>
<td>314</td>
<td>1700</td>
<td>4201.9</td>
</tr>
<tr>
<td>2012</td>
<td>7232</td>
<td>296</td>
<td>1688</td>
<td>4424.1</td>
<td>4043.2</td>
<td>5519</td>
<td>2013</td>
<td>7086</td>
<td>277</td>
<td>1647</td>
<td>3929.6</td>
</tr>
</tbody>
</table>
5 Industry-level Productivity Growth, Data treatment

We measure the contribution of resource reallocation between dairy farms to industry-level TFP growth by applying the adjusted OP decomposition method (Equations (4) and (5)) to our farm-level estimates of TFP and market share. This method allows us to identify the resources being reallocated between two production systems in the six states, and estimate the contribution to industry-level productivity growth that is generated through this mechanism. This section describes our findings and compares the results before and after deregulation in 2000.

5.1 Industry-level input, output and productivity growth

The Australian dairy industry has experienced good productivity growth over the past three and a half decades. Between 1979 and 2013, industry-level TFP grew at 1.1 per cent a year (Figure 3), driven by output expansion (0.6 per cent a year) and input saving (-0.5 per cent a year). The growth in TFP reflects improvement in the efficiency with which inputs are used to produce milk and other dairy products. In turn, this growth helped strengthen the competitiveness of Australian dairy farms in the international market, and contributes to the profitability of these farms.

Figure 3 Output, Input and TFP in the Australian Dairy Industry: 1979-2013

Source: Authors’ estimates

It is widely believed that the deregulation reforms implemented in 2000 played an important role in re-shaping the structure of the dairy industry and thereby boosted industry-level
productivity growth (Edwards 2003). As shown in Figure 3, industry-level TFP grew at 1.3 per cent a year after 1999, 30 per cent faster than during the pre-reform period (1979-1999). This is in contrast to the finding of Kompas and Che (2006) that the average ‘technical efficiency’ of individual dairy farms declined in the post-reform period.

The difference between the studies can be attributed to two factors. First, TFP growth at farm level can happen when farmers apply existing technology more efficiently (and thereby improve ‘technical efficiency’) or use an improved technology. Therefore, change in ‘technical efficiency’ identified by Kompas and Che (2006) explains only a part of farm level TFP movement (represented by Δ\(\overline{\pi}_t\) in equation 3). Second, as explained in Section 3, resource allocation between farms (represented by the term of \(\text{cov}_t\) in equation 3) is an additional source of TFP growth at the industry level. It appears that the divergence between industry and farm-level TFP trends after 2000 implies that the deregulation reforms are most likely to have influenced industry-level productivity by removing barriers to movement of resources between farms and thereby changing the structure of the dairy industry.

Figure 3 shows that patterns of growth in output and input differed after 2000 – another source of evidence suggesting that the deregulation reforms had an impact on the TFP growth in the dairy industry. Specifically, industry-level TFP growth was mainly driven by outputs growing more rapidly (1.7 per cent a year) than inputs (0.7 per cent a year) before the deregulation reforms. However, in the post-reform period, industry-level TFP growth was driven by reduced input use (-2.1 per cent a year) which outstripped output decline (-0.9 per cent a year). Most breakthroughs in technology, and in particular the adoption of input-saving production technologies by dairy farms (i.e. rotary dairies, artificial insemination, pasture improvement) took place before the 1990s (Harris 2011), and as such, the marked change in the underlying drivers of industry-level TFP growth after 2000 (i.e. towards input-saving) supports the proposition that the main impact of deregulation was altering the structure of the dairy industry.

### 5.2 Resource reallocation between farms and its contribution to productivity growth

Applying Equations (2) and (3) to our farm-level data, we estimate industry-level TFP growth and decompose it into within-farm effects (mainly technological progress) and resource reallocation effects (Table 2). Over the entire survey period (1979-2013), resource reallocation between farms appears to have a negative effect on industry-level TFP growth. Specifically, unweighted farm-level TFP is estimated to grow at 1.3 per cent a year, faster than industry-level TFP growth of 1.1 per cent a year, indicating that some resources have been misallocated between farms, and that this has detracted from industry-level TFP growth by 0.1 per cent a
Resource Reallocation and Productivity Growth in the Dairy Industry

ABARES

year. In turn, this implies that within-farm technological progress has driven the productivity growth of the dairy industry, and that over the period as a whole, market or institutional barriers have restricted the movement of resources to the most productive farms.

Table 2 Resource Reallocation and Its Contribution to the Industry-level TFP

<table>
<thead>
<tr>
<th>Year</th>
<th>TFP LEVELS(^a) (in logarithm)</th>
<th>Annual % TFP Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aggregate unweighted COV</td>
<td>Aggregate unweighted COV</td>
</tr>
<tr>
<td>1979-2013</td>
<td>0.478 0.399 0.078</td>
<td>1.1 1.3 -0.1</td>
</tr>
<tr>
<td>1979-1990</td>
<td>0.279 0.178 0.098</td>
<td>0.9 0.7 0.2</td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.451 0.367 0.083</td>
<td>1.7 2.3 -0.6</td>
</tr>
<tr>
<td>2000-2013</td>
<td>0.669 0.610 0.058</td>
<td>1.9 1.8 0.2</td>
</tr>
</tbody>
</table>

Note: In the process of calculating farm-level TFP (described in Section 3), a farm is chosen to be the numeraire and its productivity level is set to 1. TFP levels of other farms in the sample are estimates relative to this farm. The estimates for TFP levels in the first two columns are averages of the samples in the relevant periods.

Source: Authors’ estimates.

Furthermore, separating the survey period into approximately decade-long sub-periods (namely, 1979-1990, 1990-2000 and 2000-2013) reveals that industry-level TFP growth and its components have not evolved evenly over time (Table 2). In particular, the average industry-level TFP growth rate has increased steadily over time, from 0.9 per cent a year from 1979 to 1990, to 1.7 per cent a year from 1990 to 2000 and to 1.9 per cent a year from 2000 to 2013. One driver of industry-level TFP growth is within-farm technological progress (represented by unweighted farm-level TFP), and this also increased over time, although not steadily, from 0.7 per cent a year from 1979-1990 to 2.3 per cent a year from 1990-2000 and to 1.8 per cent\(^2\) a year from 2000-2013. Similar to the period as a whole, unweighted farm-level TFP growth dominates industry-level TFP growth in each sub-period, supporting the finding that within-farm technological progress is consistently an important driver of productivity in the Australian dairy industry.

In contrast, contribution of resource reallocation between farms to the industry-level TFP growth shows a distinct pattern. In particular, resource reallocation contributed almost 0.2 per cent a year to industry-level TFP growth between 1979 and 1990, but subtracted 0.6 per cent a year from 1990-2000 to 1.8 per cent a year from 2000-13 may be partly attributable to the decline in technical efficiency (Kompas and Che 2006).
year between 1990 and 2000. Following deregulation in 2000, resource reallocation contributed 0.2 per cent a year to industry-level TFP growth, helping to offset a slowdown in within-farm TFP growth. Generally, the contribution of resource reallocation between farms to industry-level TFP growth tends to increase when within-farm technological progress slows, suggesting that the two effects are, to some extent, substitutes (Sheng et al. 2015).

Figure 4 Contribution of Resource Reallocation to Industry-level TFP Growth: 1979-2013

Source: Authors' estimates.

Finally, comparing resource reallocation effects before and after the deregulation reforms shows that the misallocation of resources between dairy farms mainly occurred in the pre-reform decade when the industry was highly regulated. During that period, government regulations generated price premiums for market-milk producers and segregated the milk market between states (Edwards 2003, Harris 2004, ADIC 2008), restricting the movement of resources to more efficient farms. The deregulation reforms introduced market competition and abolished long-standing institutional barriers. In turn, this facilitated structural adjustment and significantly improved the efficiency of resource reallocation within the industry.

5.3 Year-round production system versus seasonal production system

Although we measure resource reallocation between dairy farms and link its change over time (in particular after 2000) to the deregulation reforms, the analysis in itself does not reveal how resources were reallocated between farms. To provide useful insights on this issue, we split the sample into two groups based on the production system they use: seasonal or year-round. Using Equations (4) and (5), the contribution of resource reallocation between farms to industry-level
TFP growth can thus be decomposed into ‘between-effects’ and ‘within-effects’. Performing this decomposition for the whole survey period (1979-2013), and for each of the three decade-long sub-periods, generates several useful insights.3

First, the contribution of resource reallocation between farms to industry-level TFP growth is more likely to be generated by the movement of resources between farms that use different production systems, rather than between farms that use the same production system. Figure 5 shows that for the period 1979 to 2013, ‘between-effects’ were positive while ‘within-effects’ were negative. More specifically, our estimates also show that over time, farms using the seasonal production system have obtained market share from those using the year-round production system. Farms using the seasonal production system generally have higher average productivity than those using the year-round production system, and so the reallocation of market share to these farms has contributed to growth in industry-level TFP.

*Figure 5 Decomposition between ‘Within-Effects’ and ‘Between-Effects’*

![Figure 5](image-url)

Source: Authors’ estimates.

Second, the gains from deregulation were mainly generated by ‘between-effects’. In particular, ‘between-effects’ were negative in the decade prior to the reform, and become positive in the decade after. This implies that the deregulation reforms helped to correct a misallocation of resources between farms using different production systems. Specifically, the reform facilitated the movement of resources from farms using the year-round production system to those using

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3 Here, we only decompose farm level TFP growth according to the two production systems. In sensitivity testing in Section 6, we introduce the state dimension into the decomposition.
the seasonal production system, reflecting the higher average productivity of farms that use the seasonal production system. Although the total quantity of resources used by the industry declined following deregulation, in relative terms, resources were reallocated between the two production systems, driven by the inherent productivity differences between them. In comparison, ‘within-effects’ were less influenced by the reform, shifting from having a negative effect on productivity in the two decades prior to 2000, to having no effect in the decade after. This implies that resource reallocation between dairy farms using the same production system is still not making its expected contribution to industry-level TFP growth.

Finally, a further decomposition of ‘within-effects’ (between farms using the year-round production system and those using the seasonal production system) revealed that the insignificant net contribution of ‘within-effects’ to aggregate productivity growth after deregulation most likely reflects negative resource reallocation effects between farms using the seasonal production system, which offset positive resource reallocation effects among farms that use the year round production system (Figure 6). The finding of negative within effects in the seasonal production system following deregulation warrants further explanation because the removal of subsidies and other controls should have the opposite effect on resource reallocation, as observed within the year-round states.

**Figure 6 Comparison of Within-Effects between the Year-Round and Seasonal Production Systems**

![Figure 6](image_url)

Source: Authors’ estimates.
Two idiosyncratic factors are likely responsible for the negative within effects in the seasonal production states following deregulation. These factors are the structural adjustment package associated with deregulation that was provided to dairy farmers in 2000-01, and droughts in 2002-03 and 2006-07. Substantially negative within-effects are observed in these years, largely reflecting negative effects on input use and hence productivity that are associated with these events. Excluding the effects of the adjustment package and drought eliminates the negative misallocation effects within the seasonal states. Appendix A contains a more detailed explanation of these effects.
6 Robustness Check

To ensure robustness of our empirical results, we tested sensitivity to three key assumptions embedded in the estimation method. First, the measure of resource reallocation between farms relies heavily on reliable estimates of farm-level productivity. To avoid a potential inaccuracy in the farm-level productivity estimates that may be caused by using the index method, we also used the Wooldridge-LP (Wooldridge 2009) regression method to estimate farm-level TFP, then repeated the decomposition exercises. The results with regard to the resource allocation were generally consistent with those obtained when using the index method.

Second, the decomposition of industry-level TFP could be sensitive to the prices used in the aggregation of real values of outputs and inputs. In particular, as composition of outputs and inputs may differ substantially between farms, the resulting farm-level TFP estimates could depart significantly from those obtained based on physical quantities of input and output (Forster et al. 2008). We estimated both and found the resource reallocation effects obtained when using revenue based TFP estimates are generally consistent with those obtained when using quantity-based TFP estimates.

Third, in order to investigate a possible bias that might be caused by restrictions on the movement of resources between states (due to either physical or market access constraints), we re-estimated 'between-effects' and 'within-effects' after re-grouping the farms into states (instead of production systems). The results show that resource reallocation between states and within states using the year-round production system made a greater contribution to aggregate productivity growth after deregulation, but this was not the case within states using the seasonal production system. In particular, the contribution to productivity growth of resource reallocation between dairy farms in Victoria (where the seasonal production system accounts for around 60 per cent of milk production) became more negative after the deregulation reforms were introduced.

In sum, the results obtained in this paper are generally robust to changes in the key assumptions underlying the methods used to estimate farm-level productivity, and to the way farms are grouped by production systems or state.
Conclusions

Reallocation of resources between farms is an important driver of aggregate productivity growth in Australian agriculture. Between 1978 and 2010, resource reallocation in the broadacre agriculture sector accounted for around half of total TFP growth, helping to offset the negative impacts of a slowdown in technological progress, adverse seasonal conditions and unfavourable international market conditions (Sheng et al. 2015). Resource reallocation could have exerted a similar influence on the productivity of the dairy industry, particularly following substantial deregulation in 2000.

This paper uses an adjusted OP decomposition method to measure the contribution of resource reallocation to industry-level productivity growth in the Australian dairy industry between 1979 and 2013. In addition, we link changes in the contribution of resource reallocation to industry-level TFP to deregulation reforms that were introduced in 2000 by comparing the pre and post-reform eras. We also investigate the mechanism through which resource reallocation has occurred by decomposing overall effects into ‘between-effects’ and ‘within-effects’ for groups of farms with different production systems.

The results show that the deregulation reforms facilitated the movement of resources from farms using the year-round production system to those using the seasonal production system, as reflected in significantly increased ‘between-effects’ in the post-reform decade. However, the impact of the deregulation reforms on the movement of resources between farms within each farm group was insignificant, mainly because of an increase in resource misallocation between farms using the seasonal production system. This finding suggests that further productivity gains from resource reallocation in the dairy industry are likely to be derived from the movement of resources between farms using the seasonal production system.
8 References


 Appendix A: A discussion on the negative within effects in seasonal production system after the dairy deregulation

Negative within effects in the seasonal production system following deregulation indicate that inputs and market share moved towards relatively low productivity farms within this production system after 2000. This is contrary to our expectation, and the opposite of the situation in the year-round states, where the removal of subsidies and other controls led to positive within effects following deregulation. Two possible causes of negative within effects among farms using the seasonal production system following deregulation are considered in this appendix: the structural adjustment package provided in 2000-01, and droughts that occurred in 2002-03 and 2006-07.

Adjustment package

Dairy farmers were provided with a structural adjustment package following deregulation. The most significant component of this package was a $1.6B payment, which was shared among farmers according to milk output in 1998-99 (or a longer period if 1998-99 was an unusually poor year). The payment to each farmer was defined as litres of market milk produced multiplied by 46.23c, plus litres of manufacturing milk produced multiplied by 8.96c. The payment could be taken in a series of quarterly instalments over 8 years, or as a lump sum. Most farmers (>80% anecdotally) took the payment upfront (i.e. in 2000-01) and most used it to buy land and other assets and to reduce debt.

This payment is likely to have led to relatively inefficient farms expanding by more than efficient farms (negative within effects) for two reasons. First, the relatively high payment attached to market milk meant that farms with market milk contracts (and hence a relatively flat supply curve throughout the year) received relatively large adjustment payments. If these farms achieved relatively constant production through the year by using many inputs in winter and other times of year when pasture growth is limited, and hence had relatively low productivity, then providing these farms with relatively large payments would have allowed them to expand by more than their more efficient seasonal-producing counterparts.

Second, because farmers received payments regardless of their productivity or profitability, the payments gave relatively inefficient farms a greater ability to compete for land than they would have had otherwise. This is consistent with the observation that a distinguishing characteristic of low productivity farms that expanded after 2000 was that they had a relatively large land area. These large farms presumably produced relatively large amounts of milk in 1998-99, and therefore received the greatest adjustment payments, which were then used to buy relatively low-productivity assets.
ABARES data indicate that the total area of land used by the dairy industry in Victoria (the main seasonal production state) increased by approximately 5 per cent in 2000-01. Assuming the most suitable land for dairy farming was already in use, much of this additional land would have been of lower quality.

The data indicate that the structural adjustment package did not create misallocation in the year-round states. One explanation for this is that only the most productive farmers remained in the year-round states following deregulation, and so these farmers could invest their payments in relatively productive assets from the pool of farms on the market at the time. In addition, given that prices fell in these states, farmers had good reason to invest in productivity-improving technologies such as rotary dairies. In contrast, in Victoria there was less of a contraction in farm numbers, and milk prices were slightly higher following deregulation, and so payments were more likely to be spent on marginal land and other relatively low-productivity assets.

**Drought**

The second main cause of negative within effects is drought. Specifically, the major droughts of 2002-03 and 2006-07 caused significant ‘misallocation’ in the seasonal production system. The main reason for this is that many farms expanded by investing in irrigation infrastructure (for example on the Murray River in South Australia) or by intensifying rainfed pasture-based systems (for example by increasing stocking rates and supplementary feeding grain).

In drought years, these farms are typically forced to purchase many more inputs (for example feed, leases of additional land and agistment of stock) and the price of inputs such as irrigation water increase dramatically. Purchasing these additional inputs makes it appear that these farms expand (and indeed their share of output might increase) but doing so is much less productive than making use of the ‘free’ rainfall input, and so the measured productivity of these farms falls. Conversely, farms that haven’t expanded through intensification experience less of an increase in input use and less of a decline in productivity when drought occurs.

Anecdotally, this shift towards intensification happened after 2000, probably partly because of deregulation, but also because of water market reform and improvements in irrigation technology (for example better centre pivots). In many cases, it took some time to develop strategies for managing the risk associated with more intensive and complicated production systems, particularly in the presence of drought.
Overall, there is misallocation of resources within the seasonal production system in all decades. This is probably because these states largely have a Mediterranean climate which means the highest-productivity system is seasonal production, but this is not ideal for milk processors (regardless of whether they supply the domestic or export markets) because it leaves factories underutilised in all months other than spring. As a result, processors offer price premiums for milk to be produced in winter and at other relatively low-productivity times of year. This means that relatively unproductive farms expand because it can be just as profitable to be low-productivity as high. Conversely, in year-round states such as New South Wales and Queensland, the climate is more uniform, and so there is less of a productivity penalty associated with producing year-round.