AN IMPROVED PRODUCTIVITY DECOMPOSITION APPROACH TO UNDERSTAND FIRM DYNAMICS AND AGGREGATE GROWTH

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First Version: 12 December 2006

This Version: 19 June 2008

Abstract

We propose a new decomposition method for analysing aggregate productivity changes. The main improvement in our proposed method is that we are clearly able to separate out pure productivity changes of a hypothetical average firm from changes in the share of output or value added between firms. Our measure solves an aggregation problem which arises in summing up firm-level contributions to aggregate productivity growth. It also allows for straightforward interpretation of the productivity contribution of entering and exiting firms.

Keywords: productivity measurement; productivity growth; industry dynamics; firm entry and exit

JEL Codes: C43, D24, E23, O47

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FIRM DYNAMICS AND AGGREGATE PRODUCTIVITY GROWTH: A CRITICAL REVIEW OF DECOMPOSITION ANALYSES

1 Introduction

Studies which focus on firm-level dynamics and the productivity gains of reallocation from less-productive to more-productive firms typically use a measure of productivity change which mistakenly conflates productivity change and market (or employment) share changes. This problem has also been identified by Fox (2004) and Petrin and Levinsohn (2005). These productivity decompositions are flawed in that they do not begin from a correct aggregate productivity change indicator.

Our contribution in this paper is to propose a new decomposition method beginning from an aggregate productivity change indicator which makes clear the multiple intra- and inter-firm contributions to increased productivity. Furthermore, our measure allows straightforward interpretation of productivity contributions of exiting and entering firms. This is of particular interest given the growing body of evidence which highlights the importance of productivity gains from entry and exit.

We apply our proposed measure to a panel of firm-level data from Australia and we show that the typical interpretation of the standard measure gives a mis-leading picture of the contribution of firm dynamics to productivity change. Our measure provides insight into the failure of the standard decomposition to correctly account for the components of productivity change. The difference between the two productivity measures is substantial and has important implications for policy and understanding productivity.

The paper proceeds as follows. We first detail the problem and our proposed solution. We then briefly discuss our data and present the results of our decomposition which we compare to findings from other studies. In the final section, we conclude.

2 Shortcomings of conventional productivity decomposition methods

Researchers have employed various decomposition methods over the years with different component terms and suggested interpretation of those components. The decomposition methods have been used on a mix of labour productivity and total factor productivity (TFP) measures. However, regardless of the actual decomposition, they are all derived from an indicator of aggregate productivity change that is defined as follows:

$$\Delta P^{A}_{0,1} = \sum \theta_{i1} P_{i1} - \sum \theta_{i0} P_{i0} \tag{1}$$

where P_i is firm-level productivity and θ_{it} is some share weight of firm *i* – typically share of industry output if P is TFP or employment share if P is labour productivity.

Both Fox (2004) and Petrin and Levinsohn (2005) highlight problems with this starting point. As elaborated below, the bases of their arguments differ but both agree that the expression in equation (1) is not purely a measure of aggregate productivity change but conflates productivity change and share change. Thus, any analysis that interprets this measure as one of ‘pure’ productivity change is potentially misleading.

Before proceeding to describe these arguments in detail, we note that studies measure TFP change either in levels or in natural logarithms. Studies tend to cross-reference results based on either measure without distinguishing between the two, but it should be acknowledged that a change in share-weighted TFP levels measures the difference in the share-weighted arithmetic mean of firm TFP levels between two periods, while a change in share-weighted *ln(TFP)* measures the natural log of the ratio of the share-weighted geometric mean of firm TFP levels between the comparison and base periods. As will be discussed below, the choice between an ‘arithmetic-mean’ or ‘geometric-mean’ definition of TFP change has implications on the way in which a decomposition accounts for the components of entry and exit in an unbalanced panel. However, whether in levels or natural logs, the problem remains that TFP change as defined in equation (1) measures more than productivity change.

Fox (2004) identifies the problem as one of measurement, namely the failure to satisfy the basic property of monotonicity in aggregation. That is, even if all firms experience an increase in productivity, aggregate productivity can fall. This paradoxical result can be shown as follows: first, divide TFP change measured as the difference in TFP levels by base period aggregate productivity to obtain the growth rate:

$$\begin{aligned}\Delta P^{A}_{0,1} &= \sum \theta_{i1} P_{i1} - \sum \theta_{i0} P_{i0} \\ &= \frac{\sum \theta_{i1} P_{i1}}{\sum \theta_{i0} P_{i0}} - 1\end{aligned} \qquad (2)$$

Equation (2) may then be rewritten to express TFP as a ratio of output (Y) to inputs (X) Assuming the index of combined inputs is constant over the two periods and dropping the subtraction of one, equation (2) may be re-expressed as:

$$\Delta P^{A}_{0,1} = \sum \theta_{i1} \left(Y_{i1} / X \right) \Big/ \sum \theta_{i0} \left(Y_{i0} / X \right) = \sum \theta_{i1} Y_{i1} \Big/ \sum \theta_{i0} Y_{i0} \qquad (3)$$

It can be seen that the output shares are not held constant in going between periods 0 and 1, and hence quantity changes are confounded with share movements. It is possible for $\sum \theta_{i1} Y_{i1} < \sum \theta_{i0} Y_{i0}$ through changing shares even while $Y_{i1} > Y_{i0}$ for every firm *i* (for the moment assuming a balanced panel).

The aggregation problem can be resolved by applying an average period share to weight the changes in TFP levels, or a Bennet (1920) indicator, as suggested in Fox (2004). This will keep shares unchanged between the two periods.

$$\Delta P^{B}_{0,1} = \sum_{i \in I} (1/2)(\theta_{i1} + \theta_{i0}) \Delta P_{i1} \qquad (4)$$

The interpretation problem with $\Delta P_{0,1}^{A}$ is further demonstrated in Fox(2004), who notes that it is a combination of the Bennet productivity-change indicator in equation (4) and an aggregate share-change indicator

$$\begin{aligned}\Delta P_{0,1}^{A} &= \sum_{i\in I}(1/2)(\theta_{i1}+\theta_{i0})\Delta P_{i1}+\sum_{i\in I}(1/2)(P_{i1}+P_{i0})\Delta\theta_{i1} \\ &= \Delta P_{0,1}^{B}+\Delta S_{0,1}^{B}\end{aligned} \tag{5}$$

From equation (5), it is clear that interpreting $\Delta P_{0,1}^{A}$ as a pure productivity change is flawed when in fact it combines productivity and share changes. Furthermore, previous decomposition studies have denoted the share change term as a between-firm 'reallocation effect', that is, the change in aggregate productivity that arises from the reallocation of output and input across firms with different productivity levels. This interpretation gives an erroneous assessment of the relative importance of firm dynamics and resource reallocation in affecting aggregate productivity growth.

Studies that have derived their decompositions from $\Delta P_{0,1}^{A}$ include Griliches and Regev (1995), Baily, Bartelsman and Haltiwanger (2001) and Baldwin and Gu (2003).

Petrin and Levinsohn (2005) point out the lack of a theoretical basis for decompositions derived from $\Delta P_{0,1}^{A}$ (or $\Delta \ln P_{0,1}^{A}$ for *ln(TFP)*) in equation (1). In particular, because $\Delta \ln P_{0,1}^{A}$ does not approximate the growth accounting measure of TFP change, productivity decomposition analyses cannot be linked to welfare changes.

Aggregate productivity growth in growth-accounting terms is approximated by a Tornqvist-Divisia index, which weights discrete changes in *ln(TFP)* by the average share weights between beginning and end period:

$$d\Omega_{1}=\sum_{i\in I}(1/2)(\theta_{i1}+\theta_{i0})\Delta\ln TFP_{i1} \tag{6}$$

where θ denotes the share of an individual firm's gross output divided by aggregate value added ('Domar (1961) weights') if TFP is measured as the residual from a gross-output production function, or the share of an individual firm's value added divided by aggregate value added if TFP is measured as the residual from a value-added production function.

Fox (2004) shows that for value-added based TFP, $\Delta \ln P_{0,1}^{A}$ decomposes into the growth accounting productivity measure and a share-change term

$$\Delta\ln P_{0,1}^{A}=\sum_{i\in I}(1/2)(\theta_{i1}+\theta_{i0})\Delta\ln P_{i1}+\sum_{i\in I}(1/2)(\ln P_{i1}+\ln P_{i0})\Delta\theta_{i1} \tag{7}$$

For gross-output based TFP, Petrin and Levinsohn show that if $\Delta \ln P^{A}_{0,1}$ is calculated using the gross-output share of firms--the case in firm-level studies--instead of Domar weights, then the measure will include a third term--an error arising from the use of the wrong share weight. This error may be thought of as arising from the failure to account adequately for the contribution to productivity gains from intermediate deliveries between firms in the economy.

Studies that have derived their decompositions from $\Delta \ln P^{A}_{0,1}$ include Foster, Haltiwanger and Krizan (2001), Disney, Haskel and Heden (2003) and Okamoto and Sjöholm (2005).

3 An alternative productivity decomposition

In this section, we present our proposed productivity decomposition. It is an extension of a proposal by Fox (2004), which we introduce first. We then discuss how we will deal with entry and exit. And, finally, we present our decomposition which solves an important aggregation problem while at the same time providing a sharpened measure of the contribution of entry and exit to productivity change.

3.1 The Fox decomposition

Fox (2004) proposes a decomposition derived from a Bennet (1920) productivity-change indicator. For a balanced panel, this is

$$\Delta P^{B}_{0,1} = \sum \theta_{i0} \Delta P_{i1} + \sum (1/2) \Delta \theta_{i1} \Delta P_{i1} \tag{8}$$

The first term on the right hand side reflects the change in productivity over two periods 0 and 1 without any share change. This first term captures within-firm improvements in productivity weighted by initial period shares. The second term denotes the contribution from the changing shares of the continuing firms interacted with productivity changes on aggregate productivity growth. This is normally known as the ‘cross effect’ in the literature.

Note that a ‘reallocation effect’ as defined in conventional decomposition methods is absent from $\Delta P^{B}_{0,1}$. It does not contain the extraneous share change term that has been interpreted as a reallocation effect. However, the cross effect can be regarded as a measure of reallocation, specifically in that it captures the productivity gains that arise from high-productivity growth firms’ expanding shares or low-productivity growth firms’ shrinking shares. For this reason, we will interpret the cross effect as a reallocation effect in what follows.

3.2 Accounting for entry and exit

Since entry and exit is integral to the analysis of dynamics at the firm level, and present in most data sets used to analyse firm-level productivity, we need to incorporate terms which capture the impact of entry and exit on overall productivity growth in the decomposition. A problem that arises is that observations on firms are made only at discrete intervals. This means that the exact time between periods 0 and 1 at which entry/exit occurs is not observed. Nor is the initial/final productivity level of the entrant/exiter observed. This poses a problem for calculation of the contribution of entry and exit to aggregate productivity change.

Petrin and Levinsohn (2005) suggest using half the beginning/end period share as weights for exiters/entrants and estimating the productivity level of firms at the time of entry/exit using later/earlier periods of observed productivity and any other relevant state variables to calculate their aggregate productivity change between periods 0 and 1. The more common practice across firm-level decomposition studies is to truncate the productivity calculation of entrants/exiters in their entering/exiting year. When the arithmetic-mean definition of TFP change is used, this reflects an implicit assumption that the productivity level is zero, which is a lower bound value. When the geometric-mean definition of TFP change is used, this reflects an implicit assumption that the productivity level is one, as the ln(0) is undefined. In fact, we would argue that for this reason the arithmetic-mean representation of TFP change is more appropriate in productivity decompositions.

For an entrant who enters after time 0 but before time 1, θ_{i0} is zero and P_{io} is unobserved. If P_{i0} is assumed to be zero equation (8) becomes:

$$\begin{aligned}\Delta P_{0,1}^{B,N} &= \sum_{i\in N}(1/2)\theta_{i1}P_{i1} + \sum_{i\in N}(1/2)\theta_{i0}P_{i1} \\ &= \sum_{i\in N}(1/2)\theta_{i1}P_{i1}\end{aligned} \tag{9}$$

The case is symmetric for exiting firms, setting θ_{i1} to zero and then the decomposition including entry and exit effects is:

$$\begin{aligned}\Delta P_{0,1}^{B} &= \sum_{i\in C}\theta_{i0}\Delta P_{i1} + \sum_{i\in C}(1/2)\Delta\theta_{i1}\Delta P_{i1} \\ &+ \sum_{i\in N}(1/2)\theta_{i1}P_{i1} - \sum_{i\in X}(1/2)\theta_{i0}P_{i0}\end{aligned} \tag{10}$$

N and *X* in equation (10) refer to the set of entering and exiting firms, respectively.

3.3 Extended-Fox decomposition

The Fox decomposition ensures that we are accounting for intra and inter-firm contributions to purely aggregate TFP growth. However, there is a potential problem with the interpretation of the entry and exit terms in this decomposition, namely, that the net entry effect can be negative even if entrants are more productive than exiters if their market shares are much lower. This issue arises because the entry and exit terms are not deviated from some reference level. It has been addressed in an earlier decomposition method used by Foster, et al. (2001) and we have taken this step to sharpen the interpretation of the entry and exit terms in Fox's decomposition to derive a new decomposition.

We deviate each term in the Fox decomposition by a scaling factor, a[1]:

$$\begin{aligned}\Delta P_{0,1}^{B} = &\sum_{i\in C}\theta_{i0}\Delta P_{i1} + \sum_{i\in C}(\tfrac{1}{2})\Delta\theta_{i1}\Delta P_{i1} \\ &+ \sum_{i\in N}(\tfrac{1}{2})\theta_{i1}(P_{i1}-a) - \sum_{i\in X}(\tfrac{1}{2})\theta_{i0}(P_{i0}-a)\end{aligned} \tag{11}$$

The decomposition in equation (11) will not sum to the share-weighted productivity change indicator $\Delta P_{0,1}^{B}$ if the shares of entrants and exiters are unequal – which is our premise in introducing the deviation. To equate both sides, we insert a correction term $\sum_{n\in C}(\tfrac{1}{2})\Delta\theta_{i1}(a)$ to the decomposition that captures changing shares in continuing firms between the two time periods. The decomposition then becomes:

$$\begin{aligned}\Delta P_{0,1}^{B} = &\sum_{i\in C}\theta_{i0}\Delta P_{i1} + \sum_{i\in C}(\tfrac{1}{2})\Delta\theta_{i1}\Delta P_{i1} - \sum_{n\in C}(\tfrac{1}{2})\Delta\theta_{i1}(a) \\ &+ \sum_{i\in N}(\tfrac{1}{2})\theta_{i1}(P_{i1}-a) - \sum_{i\in X}(\tfrac{1}{2})\theta_{i0}(P_{i0}-a)\end{aligned} \tag{13}$$

The additional terms $\tfrac{1}{2}(a)[(\sum_{n\in C}\theta_{i0} + \sum_{n\in X}\theta_{i0}) - (\sum_{n\in C}\theta_{i1} + \sum_{n\in N}\theta_{i1})]$ sum to zero because $\sum_{n\in C\cup N}\theta_{n}^{1} = \sum_{n\in C\cup X}\theta_{n}^{0} = 1$

a is an arbitrary scalar, but we follow Balk (2003) in using the average aggregate productivity level between the two periods $(P_1 + P_0)/2$.

The extended-Fox decomposition comprises five terms on the right hand side. The first two terms represent the fractions of industry productivity change attributable to within-firm changes and between-firm cross effect among incumbents, as in the original Fox decomposition. The third term can be inferred as the contribution to aggregate productivity growth arising purely from continuing firms' changing market shares weighted by the average aggregate productivity, or 'pure share' changes. The fourth and fifth terms measure the contribution from entry and exit. The entry term will be positive if new firms on the whole have higher than average industry productivity, and the exit term will be positive if firms that go out of business have lower than average aggregate productivity.

[1] When productivity level in each period is deviated by a, $\Delta P_{i1} = (P_{i1}-a)-(P_{i0}-a)$, so the first two terms for the continuing firms are unchanged from the Fox decomposition.

Since our TFP estimates are derived from a value-added production function, we use firms' shares of value added as weights. When a change in TFP level (as opposed to *ln(TFP)*) is measured, this formulation (and the decomposition derived from it) is not invariant to the units of measurement. For example, if all outputs are rescaled by $\lambda > 0$ (such as due to a change in the monetary units of measuring output), then $\Delta P^{B}_{0,1}$ can be scaled up by λ, as follows:

$$\begin{aligned}\Delta\tilde{P}^{B}_{0,1} &= \sum_{i\in I}(1/2)(\theta_{i1}+\theta_{i0})\left[\left(\lambda Y_{i1}/X_{i1}\right)-\left(\lambda Y_{i0}/X_{i0}\right)\right] \\ &= \lambda\left[\sum(1/2)(\theta_{i1}+\theta_{i0})\left[\left(Y_{i1}/X_{i1}\right)-\left(Y_{i0}/X_{i0}\right)\right]\right] \\ &= \lambda\Delta P^{B}_{0,1}\end{aligned} \tag{14}$$

This issue will not arise if all inputs and outputs are always measured in the same units. However, in order to avoid potential problems with units of measurements confounding interpretation, researchers typically implement some form of normalisation. In this paper, we will normalise the TFP change between beginning and ending periods, by dividing equation (13) by $\Delta P^{B}_{0,1}$ on both sides, so that the decomposition constituents become additive contributions to aggregate productivity change that is normalized to one.

4 Application to Australian firm-level data

4.1 Data description

The decomposition derived in this study is applied to data from the Business Longitudinal Survey (BLS) of the Australian Bureau of Statistics (ABS) to analyse the contribution of firm dynamics to aggregate productivity growth in twenty-five Australian manufacturing and service industries at the 2-digit Australian and New Zealand Standard Industrial Classification (ANZSIC) level. The panel covers four years from 1994-95 to 1997-98 and comprises around 5600 firms.

The analysis was carried out on two samples of the BLS: the publicly available CURF (Confidentialised Unit Record File) that excludes data on firms with more than 200 employees or very large sales and the MURF (Main Unit Record File), which contains information on all firms in the survey. At the 2-digit ANZSIC level, the CURF sample comprises only firms with less than 100 employees, so as to preserve confidentiality. The MURF sample, with its inclusion of large and medium sized firms, is more representative of the business population. Comparison of the results from the two samples enables us to identify possible differences in the productivity dynamics of small businesses. In what follows, we will refer to these as the 'small-firm' sample (CURF) and the 'full' sample (MURF).

The BLS covers only the non-agricultural market sector and excludes industries with heavy government involvement, such as health and education and communication services. A number of industries in the BLS have been excluded from our analysis, for reasons of insufficient observations or measurement problems. In total, we analyse 23 industries in the small-firm sample and 25 industries in the full sample.

Firm-level total factor productivity indices (TFPs) were constructed from production function estimates, estimated using the methodology of Olley and Pakes (1996) which incorporates firm-specific productivity differences and endogenises firm exit decisions[2]. Aggregate productivity for each 2-digit industry was then obtained as the sum of firm-level TFP weighted by each firm's share of industry value added (market share).

4.2 Results

The results of the extended-Fox decomposition are presented in Tables 1 and 2 for industries in the small-firm and full samples, respectively. As explained above, we normalize the TFP change from 1994-95 to 1997-98 to one for industries that had TFP growth and to minus one for those with a decrease in TFP.[3] The decomposition gives the share contributions of five components towards an industry's TFP change: the within-firm TFP change, the between-firm cross (reallocation) effect, the contribution from the pure market share change, and entry and exit effects.[4] In the analysis below, we will not give attention to interpreting the pure share change term, which does not have any intrinsic economic meaning. The entry and exit terms from our improved decomposition, which we believe can be interpreted as true entry and exit effects, produce this pure share change term as an artefact.

A foremost observation is that firm entry and exit and changing market shares play a substantial role in contributing to aggregate productivity growth in Australia. This seems to be especially so for small businesses. Where industries experience positive TFP growth, the contributions from the between-firm cross effect and net entry are considerable. In particular, there are industries where productivity gains arise solely through firm dynamics, as the within-firm effect is negative.

Within-firm change versus between-firm cross effect. Among the continuing firms, the between-firm cross effect is an important component in contributing towards TFP increase or compensating for TFP decline. All industries except Sports and recreation, Personal services (small-firm sample) and Printing, publishing and recorded media (full sample) have positive reallocation effects.

In the small-firm sample, four of eleven industries with overall TFP gains see a decline in within-firm productivity performance. Yet they achieve overall productivity gains, due either solely, or in part, to a dominant reallocation effect. Of the thirteen industries in the full sample, there are three of them with overall productivity growth despite within-firm productivity decreases. For these industries, across the two samples, reallocation among

[2] See Breunig and Wong (2005) for detail of the estimation technique and Breunig and Wong (2008) for the detailed regression results and more information about the data.
[3] Appendix Table A1 contains the percentage TFP growth for the four years covered by our sample.
[4] Net entry and exit rates in our data range from 10 to 25 per cent, on the low range for OECD countries.

incumbents accounts for between 50 and 100 per cent of all positively contributing components to the TFP increase.[5] The lower incidence of industries in the full sample with positive TFP growth and negative within-firm contributions may point to the greater importance of firm dynamics in generating TFP growth in the small business sector. That is, the small firms are individually not very productive, but aggregate growth gets a boost from their entry and exit and output reallocation across continuing firms with differing productivity growth rates.

Where industries experiencing TFP improvements have both positive between-firm cross effects and positive within-firm changes, the share of the former is relatively large. In the small-firm sample, the share of the cross effect among the positively contributing terms ranges between 30 and 60 per cent in industries such as Printing, publishing and recorded media and Accommodation, cafes and restaurants, and is small only in Property services (2 per cent). In the full sample, the cross-effect shares exceed 50 per cent in quite a number of industries, for example, in the retail subdivisions of Food retailing and Motor vehicle retailing and services, while the range is between 10 and 30 percent in other cases. Only Business services has a small cross-effect share of 4 percent.

For industries recording a decrease in TFP, often stemming from a strongly negative within-firm TFP change, output reallocation from low to high productivity growth incumbents generally has a considerable effect in countering the decline. In the small-firm sample, only two of the 12 industries which record a decrease in productivity– Wood and paper product and Food retailing – have weak compensating cross effects (with shares of less than 10 percent of the negatively contributing parts). For the 12 industries in the full sample with an overall decrease in TFP, the compensating cross effect share is usually above 10 percent (for example, in Non-metallic mineral product), and over 50 percent in a few industries, reaching a maximum of 69 percent in Machinery and motor vehicle wholesaling. This share is below 10 percent only in Metal product.

Net entry effect. The net entry effect is the sum of the entry and exit effects. The vast majority of industries register a positive net entry effect. In the majority of cases, the positive net entry contribution arises from a positive exit effect dominating over a negative entry effect. A positive exit effect prevails in around 80 percent of the industries. Exiting firms predominantly have below industry average productivity level, which provides strong support for the hypothesis that firms leave due mainly to poor performance. Hence, their exit will raise aggregate productivity. Entrants contributing negatively to TFP change occur in over half of the industries. The greater likelihood of a negative entry effect is not surprising given that many of them are probably still learning within the short time period covered by our data. For industries that enjoy a positive entry effect, new firms may have entered the market with some efficiency advantages.

[5] The contribution of the 'between' effect can also be quantified as a share of all components, which is what other studies tend to do. For example, in the Food, beverage and tobacco industry in CURF (Table 1), the between-firm contribution is 179 percent of total TFP change (while the within-firm share is minus 20 percent), OR 89 percent of all the positively contributing terms. Since we have a fair number of industries with between shares that is over 100 or even 200 percent, we deem that the 'true' sense of contribution by the between effect is better conveyed by representing it as a proportion of all positively contributing terms. But we have to note this difference when comparing our results with percentages quoted in other research.

Table 1 Productivity decomposition using public-use dataset (CURF)

Industry	ANZSIC	Within-firm	Between-firm	Pure share change	Entry	Exit	TFP change	Net entry effect[1]
		Share of components in normalised TFP change (1995-98)						
Manufacturing	C							
Food, Beverage and Tobacco	21	-0.155	1.686	-0.698	-0.010	0.176	1.000	0.166
			(91.0) [2]					*(9.0)*
Textile, Clothing, Footwear and	22	-1.707	0.634	0.000	-0.013	0.085	-1.000	0.072
Leather			*(37.2)*					*(4.2)*
Wood and Paper Product	23	-1.059	0.088	-0.140	-0.066	0.177	-1.000	0.111
			(7.3)					*(9.2)*
Printing, Publishing and Recorded	24	1.126	2.279	-2.959	-0.077	0.630	1.000	0.553
Media			*(57.6)*					*(14.0)*
Petroleum, Coal, Chemical and	25	-1.065	0.263	-0.284	-0.031	0.116	-1.000	0.085
Associated Product			*(19.5)*					*(6.3)*
Non-Metallic Mineral Product	26	-2.895	1.176	0.739	-0.007	-0.013	-1.000	-0.020
Manufacturing			*(40.4)*					
Metal Product	27	-1.530	0.734	-0.398	0.100	0.094	-1.000	0.194
			(38.1)					*(10.1)*
Machinery and Equipment	28	-1.469	0.749	-0.366	-0.004	0.090	-1.000	0.085
			(40.8)					*(4.7)*
Other	29	-1.340	0.641	-0.274	-0.052	0.025	-1.000	-0.027
			(39.1)					
Construction	E							
General Construction	41	-1.360	2.872	-1.219	-0.050	0.757	1.000	0.707
			(80.2)					*(19.8)*
Construction Trade Services	42	-1.134	1.141	0.393	0.493	0.108	1.000	0.600
			(53.5)					*(28.1)*
Wholesale Trade	F							
Basic Material Wholesaling	45	-2.341	1.315	-0.091	0.063	0.055	-1.000	0.117
			(54.1)					*(4.8)*
Machinery and Motor Vehicle	46	-1.238	0.371	-0.090	0.027	-0.070	-1.000	-0.043
Wholesaling			*(27.1)*					
Personal and Household Good	47	-1.671	0.476	0.054	0.118	0.024	-1.000	0.142
Wholesaling			*(28.5)*					*(8.5)*
Retail Trade	G							
Food Retailing	51	-0.967	0.010	-0.043	-0.038	0.037	-1.000	-0.001
			(1.0)					
Personal and Household Good	52	0.798	0.394	-0.110	-0.097	0.015	1.000	-0.082
Retailing			*(33.1)*					
Motor Vehicle Retailing and	53	-1.573	1.323	-0.620	-0.013	-0.117	-1.000	-0.130
Services			*(56.9)*					
Accommodation, Cafes and	H/57	0.280	0.506	0.115	0.054	0.045	1.000	0.099
Restaurants			*(50.6)*					*(9.9)*
Property and Business Services	L							
Property Services	77[3]	0.856	0.019	0.078	0.003	0.044	1.000	0.047
			(1.9)					*(4.7)*
Business Services	78	-0.206	1.246	-0.028	-0.073	0.061	1.000	-0.012
			(100.0)					
Cultural and Recreational Services	P							
Motion Picture, Radio and	91	1.059	0.619	-0.980	-0.005	0.306	1.000	0.301
Television Services			*(31.3)*					*(15.2)*
Sport and Recreation	93	0.912	-0.031	0.089	-0.021	0.051	1.000	0.030
								(2.9)
Personal and Other Services	Q							
Personal Services	95	1.205	-0.164	0.033	-0.023	-0.052	1.000	-0.075

Notes:

1. Net entry effect sums the entry and exit components in the fourth and fifth columns.

2. In industries with positive TFP change, this number represents the share of between effect among all positively contributing components.
In industries with negative TFP change, it is the share of between effect that compensates for the negatively contributing components.
This figure is provided for all positive between effect and positive net entry terms.

Table 2 Productivity decomposition using complete dataset (MURF)

Industry	ANZSIC	Within-firm	Between-firm	Pure share change	Entry	Exit	TFP change	Net entry effect[1]
		Share of components in normalised TFP change (1995-98)						
Manufacturing	C							
Food, Beverage and Tobacco	21	0.821	0.295 *(21.6)*[2]	-0.365	-0.010	0.259	1.000	0.248 *(18.2)*
Textile, Clothing, Footwear and Leather	22	-0.809	0.207 *(15.5)*	-0.532	0.002	0.132	-1.000	0.134 *(10.1)*
Wood and Paper Product	23	-1.657	1.174 *(54.0)*	-0.509	-0.019	0.012	-1.000	-0.007
Printing, Publishing and Recorded Media	24	-0.344	-0.064	-0.345	0.019	-0.266	-1.000	-0.247
Petroleum, Coal, Chemical and Associated Product	25	-0.891	0.155 *(13.2)*	-0.283	-0.007	0.027	-1.000	0.020 *(1.7)*
Non-Metallic Mineral Product Manufacturing	26	-0.378	0.201 *(15.1)*	-0.952	-0.005	0.134	-1.000	0.129 *(9.7)*
Metal Product	27	-0.208	0.090 *(5.6)*	-1.402	0.014	0.506	-1.000	0.520 *(32.3)*
Machinery and Equipment	28	-2.394	1.843 *(60.8)*	-0.639	-0.003	0.193	-1.000	0.190 *(6.3)*
Other	29	-2.627	4.177 *(99.1)*	-0.588	-0.036	0.074	1.000	0.038 *(0.9)*
Construction	E							
General Construction	41	-0.750	0.397 *(17.5)*	-1.516	0.008	0.861	-1.000	0.868 *(38.3)*
Construction Trade Services	42	0.531	0.306 *(30.6)*	0.049	0.117	-0.003	1.000	0.114 *(11.4)*
Wholesale Trade	F							
Basic Material Wholesaling	45	-1.311	0.318 *(22.5)*	-0.099	0.050	0.043	-1.000	0.093 *(6.6)*
Machinery and Motor Vehicle Wholesaling	46	-2.976	2.354 *(68.6)*	-0.455	0.049	0.029	-1.000	0.078 *(2.3)*
Personal and Household Good Wholesaling	47	0.431	0.537 *(53.4)*	-0.007	0.013	0.025	1.000	0.038 *(3.8)*
Retail Trade	G							
Food Retailing	51	0.446	0.668 *(58.5)*	-0.141	-0.003	0.029	1.000	0.027 *(2.3)*
Personal and Household Good Retailing	52	-1.257	3.018 *(100.0)*	-0.611	-0.026	-0.124	1.000	-0.150
Motor Vehicle Retailing and Services	53	0.515	0.677 *(56.8)*	-0.184	-0.025	0.018	1.000	-0.007
Accommodation, Cafes and Restaurants	H/57	-0.470	0.734 *(22.1)*	-2.846	-0.013	1.595	-1.000	1.583 *(47.7)*
Transport and Storage	I							
Road Transport	61	0.930	0.479 *(19.9)*	-1.908	0.020	-0.521	-1.000	-0.501
Services to Transport	66	-0.963	0.939 *(47.8)*	0.260	0.849	-0.084	1.000	0.765 *(39.0)*
Property and Business Services	L							
Property Services	77	0.281	0.659 *(65.9)*	0.044	-0.006	0.022	1.000	0.016 *(1.6)*
Business Services	78	1.272	0.052 *(3.7)*	-0.406	-0.024	0.107	1.000	0.083 *(5.9)*
Cultural and Recreational Services	P							
Motion Picture, Radio and Television Services	91	0.398	0.892 *(64.1)*	-0.392	-0.002	0.105	1.000	0.102 *(7.4)*
Sport and Recreation	93	1.637	-0.470	-0.316	0.000	0.149	1.000	0.149 *(8.3)*
Personal and Other Services	Q							
Personal Services	95	0.848	0.116 *(11.6)*	0.011	0.041	-0.017	1.000	0.024 *(2.4)*

Notes:

1. Net entry effect sums the entry and exit components in the fourth and fifth columns.

2. In industries with positive TFP change, this number represents the share of between effect among all positively contributing components.

In industries with negative TFP change, it is the share of between effect that compensates for the negatively contributing components.

This figure is provided for all positive between effect and positive net entry terms.

The contribution of a positive net entry effect to TFP change is not negligible. Where the net entry effect is positive, in industries enjoying TFP increases, in the small-firm sample, net entry accounts for 8 to 28 per cent of the positively contributing portions of TFP. The share from positive net entry is mostly below 10 per cent in the full sample.

As for industries with negative TFP change, positive net entry contributes between 4 and 10 per cent to countering the negative terms in the small-firm sample, for example, in Metal product and Basic material wholesaling. The compensation is generally below 10 percent in the full sample, but exceeds 30 percent in a few cases, like in General construction and Accommodation, cafes and restaurants.

4.3 Comparison with other findings

A sizeable number of decomposition analyses have been conducted on data in both industrial and developing economies since the 1990s. Although these studies differ in decomposition methods, industry and time period coverage and thus are not exactly comparable, they have shown that firm dynamics and the resulting market share reallocation could be a key contributor to aggregate productivity growth (see reviews in Bartlesman and Doms (2000) and Ahn (2001)). Our results add further to this evidence.

Although there are issues with the aggregate productivity change indicator that was used to derive the decompositions in earlier studies, they do not invalidate findings of whether the within-firm effect and the entry and exit effects contribute positively or negatively to aggregate productivity change. Thus, we can compare the direction of these effects across studies.

Net entry has been identified in many studies as having a significant and positive impact on aggregate productivity growth, for example, in Foster et al. (2001) using US manufacturing data and Hahn (2000) using Korean manufacturing data. These studies show that positive net entry comes primarily from the positive effect of unproductive firms exiting the market. Evidence on the contribution from productive entrants is more mixed. Our results, using Australian data, provide additional evidence for these stylized facts. We find the predominance of positive exit effects and (small) negative entry effects as does Bartelsman et al. (2004) for a range of developed and developing economies.

There are very few decomposition studies using service sector data but available evidence indicates that market share reallocation through entry and exit is more important for the productivity growth of service industries relative to manufacturing (Foster et al. 2006; van der Wiel 1999). We cannot draw the same conclusion from our results, as firm dynamics has been important in both service and manufacturing industries. However, industries that see the greatest and smallest contributions to productivity growth from firm dynamics are in the service sector, which accords with Scarpetta et al. (2002) who note that service industries show more varied outcomes. Specifically on the retail trade sector, we do not find that net entry is important, unlike in the US (Foster et al. 2006) and the UK (Haskel and Sadun 2005), but between-firm reallocation effects accounted for a substantial share of TFP growth in the retail trade industries in Australia.

For Australia, the 1990s was an important period of substantial TFP growth. However, there has been very little analysis of firm-level data from this period. Bland and Will (2001) are the only other study of which we are aware that uses firm-level data and provides a decomposition of productivity growth for this period. (They use our small-firm sample only.) They conclude, from an analysis of labour productivity at the 1-digit industry level, that the bulk of productivity changes come from within-firm improvements in productivity and very little from entry and exit. (They find net entry has a negative effect on productivity in half of the industries they study.) Their results are based upon a decomposition of $\Delta P^{A}_{0,1}$, which contains erroneous reallocation effects as we point out in section 2 above. One point on which our results accord with theirs is the observation that both departing firms and entrants tended to have lower than average (labour) productivity.

Most studies that report results on between-firm cross effects decompose labour productivity growth and find that the cross effect was negative (for example, in Bartelsman et al. (2004)). This would imply that firms experiencing an increase in productivity were losing market share. Our decomposition of TFP changes in different industries has yielded cross effects that are mainly positive. A positive cross effect was also found in the TFP growth decomposition in Disney et al. (2003) for the UK manufacturing sector. These results could be reconciled if incumbent firms raised labour productivity mainly by increasing capital intensity (for example, through downsizing), while those that have become more efficient (in terms of TFP) have gained market shares.

Petrin and Levinsohn (2005) propose a decomposition derived from a measure of the *change* in aggregate productivity growth rates, the latter computed in accordance with the growth-accounting definition. Their decomposition produces a reallocation effect which is market share changes interacted with individual firms' average productivity growth. Using Chilean manufacturing data, the authors found that reallocation effects were almost universally positive. In their case, firms with higher growth rates gained larger market shares and contributed positively to changes in productivity growth rates. Petrin and Levinsohn's decomposition and interpretation of the reallocation effect offers another perspective on the study of the link between firm dynamics and aggregate productivity growth.

5. Discussion and conclusions

Standard decomposition methods for analysing productivity are based upon an indicator of aggregate productivity change which is the difference between productivity at one time period and a second time period, with firm-level productivity at each time period weighted by the share of the firm's output at that time period. This measure suffers from an aggregation problem, namely that the direction of overall productivity change may be positive even when all firm's productivity has decreased. We have shown that this measure, which we have called $\Delta P^{A}_{0,1}$, is actually a combination of a productivity change (weighted by the firm's average share of output at both periods) and a change in the share of firm output (weighted by the firm's average productivity at both periods.) We have argued that it is only the first of these two that should be interpreted as a productivity change. Similar criticisms have been made by Fox (2004) and Petrin and Levinsohn (2005).

We then derive a decomposition of the correct productivity change indicator which is valid in the presence of entry and exit. To remove any possible non-monotonicity from the decomposition, we analyse deviations of firm-level productivity from a reference point which we choose to be the industry average productivity. This incorporates an idea first proposed by Foster, et al. (2001), but applied, in our view, to an incorrect productivity change indicator.

The resulting decomposition measure, which we call the extended-Fox measure as it is based upon his suggestion to use $\Delta P^{B}_{0,1}$, provides a measure which captures only productivity changes, not share changes, and which provides clearly separated effects of increases in within-firm productivity, productivity increases from reallocation amongst firms, entry, and exit. In our application to Australian data, we show that re-allocation, entry and exit are all important contributors to aggregate productivity growth. The main implication of using $\Delta P^{B}_{0,1}$ instead of $\Delta P^{A}_{0,1}$ is that aggregate productivity growth is generally over-stated by the use of $\Delta P^{A}_{0,1}$. The degree of over-statement varies quite a bit by industry--see Table A1 in the appendix for a comparison of the two measures.

Our proposal does not negate previous research efforts, but it does call for a re-interpretation of results. Firstly, what has been commonly interpreted as a between-firm ‘reallocation effect’, that is, the term that captures market share changes across firms with different productivity levels, should now be recognised as an extraneous share change term that does not contribute to aggregate productivity growth.

Secondly, the magnitudes of aggregate productivity change and the shares accounted for by different intra and inter-firm components are incorrect without re-computation that removes the share change term which is erroneously included in the standard measure, $\Delta P^{A}_{0,1}$. While the share of these components in total productivity change will be different once this share change term is removed, the direction of effects--i.e., whether the within-firm effect and the entry and exit effects contribute positively or negatively to aggregate productivity change--remain valid.

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Appendix

Table A1: Difference in aggregate productivity change calculated from $\Delta P_{0,1}^{A}$ and $\Delta P_{0,1}^{B}$ (compound annual growth rates, %, 1994 - 1998)

		small -firm sample		full sample	
Industry	ANZSIC	TFP-A[1]	TFP-B[2]	TFP-A	TFP-B
Manufacturing	C				
Food, Beverage and Tobacco	21	1.4	1.4	9.6	6.1
Textile, Clothing, Footwear and Leather	22	-2.2	-3.1	-2.5	-6.7
Wood and Paper Product	23	-2.2	-3.1	0.9	-0.6
Printing, Publishing and Recorded Media	24	3.0	0.6	-2.0	-4.5
Petroleum, Coal, Chemical and Associated Product	25	-3.1	-3.9	-3.1	-4.1
Non-Metallic Mineral Product	26	-2.2	-1.5	2.0	-5.1
Metal Product	27	1.1	-1.2	2.1	-1.7
Machinery and Equipment	28	-2.6	-4.4	0.5	-1.7
Other	29	-2.7	-3.3	1.8	1.0
Construction	E				
General Construction	41	8.5	1.2	7.0	-2.4
Construction Trade Services	42	1.0	2.3	2.7	4.4
Wholesale Trade	F				
Basic Material Wholesaling	45	-3.0	-2.3	-3.4	-3.7
Machinery and Motor Vehicle Wholesaling	46	-3.0	-4.0	0.3	-1.2
Personal and Household Good Wholesaling	47	-2.7	-3.3	4.5	6.6
Retail Trade	G				
Food Retailing	51	-2.3	-5.0	3.2	3.8
Personal and Household Good Retailing	52	3.2	3.1	1.2	0.8
Motor Vehicle Retailing and Services	53	-0.5	-1.7	6.2	4.8
Accommodation, Cafes and Restaurants	H/57	4.1	4.5	8.1	-3.0
Transport and Storage	I				
Road Transport	61	-	-	2.0	-0.3
Services to Transport	66	-	-	3.0	1.2
Property and Business Services	L				
Property Services	77	11.7	14.1	9.5	8.4
Business Services	78	3.4	4.2	3.0	3.7
Cultural and Recreational Services	P				
Motion Picture, Radio and Television Services	91	6.4	3.7	2.5	1.2
Sport and Recreation	93	10.3	10.2	4.4	6.2
Personal and Other Services	Q				
Personal Services	95	3.0	4.1	3.1	5.0

1. TFP-A: Aggregate TFP in each year is the sum of individual firm TFP weighted by the share of their output in that year.
2. TFP-B: Aggregate TFP in each year is the sum of individual firm TFP weighted by the arithmetic mean of share of their output in the first and last year.