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Aggregate Growth: What
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ABSTRACT/RÉSUMÉ

This paper provides a synthesis of what is known about the determinants of output growth based on studying microeconomic data sets. It starts with a summary of the theoretical explanations which help reconcile heterogeneous performance observed across establishments in the same sector. The related theoretical literature on creative destruction models of growth is also discussed. This is followed by a review of the recent empirical literature on the relationship between microeconomic and macroeconomic productivity growth. The final section discusses the main empirical findings, the caveats of interpretation and the main issues of interpretation underlying the relationship between reallocation and growth.

JEL classification: D24, O12

Keywords: Industry productivity, reallocation, establishment level data

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Ce papier document une synthèse de l'état des connaissances des déterminants de la croissance sur la base de l'étude de données microéconomiques. Il commence par un résumé des explications théoriques aidant à expliquer l'existence des performances hétérogènes observées entre les établissements au sein d'un même secteur. La littérature théorique correspondante sur les modèles de destruction créatrice est également discutée. Suit une revue de la littérature empirique récente à propos des relations entre la croissance de la productivité aux niveaux microéconomique et macroéconomique. La dernière section discute des principaux constats empiriques, les problèmes d'interprétation sous-jacents à la relation entre réallocation et croissance.

Classification JEL : D24, O12

Mots-clés : Productivité sectorielle, réallocation, données individuelles d'établissement

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AGGREGATE GROWTH: WHAT HAVE WE LEARNED FROM MICROECONOMIC EVIDENCE?

John Haltiwanger¹

1. Overview

1. Recent research using establishment and firm level data has raised a variety of conceptual and measurement questions regarding our understanding of aggregate growth.² Several key, related findings are of interest. First, in a well functioning market economy, there is large-scale, ongoing reallocation of outputs and inputs across individual producers. Second, the pace of this reallocation varies over time (both secularly and cyclically) and across sectors. Third, much of this reallocation reflects within rather than between-sector reallocation. Fourth, there are large differentials in the levels and the rates of growth of productivity across establishments within the same sector. The rapid pace of output and input reallocation along with differences in productivity levels and growth rates are the necessary ingredients for the pace of reallocation to play an important role in aggregate productivity growth. Indeed, the core finding in the recent empirical literature exploring micro datasets to look at questions of aggregate growth is that reallocation does contribute significantly to aggregate productivity growth. For example, for the US manufacturing sector, roughly half of total factor productivity growth over the course of a decade can be accounted for by the reallocation of outputs and inputs away from less productive to more productive businesses.

2. That reallocation contributes positively to growth is precisely what one would hope and expect from a healthy, dynamic market economy. Of course, the idea that productivity growth in a market economy invariably involves restructuring and reallocation across producers is not new. For example, Schumpeter (p. 83, 1942) coined the term, “creative destruction”, which he described as follows:

“The fundamental impulse that keeps the capital engine in motion comes from the new consumers’ goods, the new methods of production and transportation, the new markets..[The process] incessantly revolutionizes from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact of capitalism.”

1. University of Maryland, Bureau of the Census, and NBER. The analyses and results presented in this paper are attributable to the author and do not necessarily reflect concurrence by the U.S. Bureau of the Census.

2. Empirical papers of relevance that focus on the connection between aggregate and micro productivity growth include: *i*) for the United States: Baily *et al.* (1992); Baily *et al.* (1996, 1997); Bartelsman and Dhrymes (1994); Foster *et al.* (2000); Dwyer (1995, 1997); Haltiwanger (1997); and Olley and Pakes (1996); *ii*) for other countries: Tybout (1996); Aw *et al.* (1997); Liu and Tybout (1996); and Griliches and Regev (1995). Much of this paper draws heavily from Haltiwanger (1997); Davis and Haltiwanger (1999); and Foster *et al.* (2000).

3. However, what is new in the emerging empirical literature is the growing availability of longitudinal establishment level data that permit characterisation and analysis of the reallocation across individual producers within narrowly defined sectors and, in turn, the connection of this reallocation to aggregate productivity growth. From these new datasets striking findings have emerged. An especially striking aspect of these findings are the respective magnitudes - the magnitude of the reallocation within narrowly defined sectors, the magnitude of the productivity differences that seemingly occur across businesses in the same narrowly defined sector and the resulting magnitude of the contribution of reallocation to growth.

4. In spite of these striking findings, it would be wrong to conclude immediately that economies that exhibit a greater pace of reallocation are inherently more efficient. It would also be wrong to suspect an immediate prediction of a simple monotonic empirical relationship between the pace of reallocation and economic growth. If nothing else, different economies (across time or country) may be experiencing different aggregate and structural shocks. Moreover, even in response to the same shocks, economies may differ fundamentally in the nature of their market structure and institutions. In this vein, there are many theoretical reasons why one might suspect that either the magnitude or the timing or the nature of the reallocation process might be inefficient (see, *e.g.* Caballero and Hammour, 2000) due to market imperfections and/or market institutions. Moreover, while the evidence suggests that reallocation does contribute positively to growth, there are various indicators of inefficiencies in the pace and timing of reallocation.

5. The paper proceeds as follows. In Section 2, a summary of theories that can account for the observed heterogeneous fortunes across establishments in the same narrowly defined sector is provided. In addition, the related theoretical literature on creative destruction models of growth is discussed. This brief discussion of theoretical underpinnings is of considerable help in putting the results on the relationship between micro and macro productivity growth into perspective. In Section 3, a review and synthesis of the recent empirical literature is presented. Section 4 contains some discussion of caveats and questions and results that raise questions about the connection between reallocation and growth. Section 5 provides concluding remarks.

2. Theoretical underpinnings

6. This section draws together theories and evidence related to the reasons for cross-sectional heterogeneity in establishment-level and firm-level outcomes. A pervasive empirical finding in the recent literature is that within-sector differences dwarf between sector differences in behaviour. For example, Haltiwanger (Table 1, 1997) shows that 4-digit industry effects account for less than 10 per cent of the cross-sectional heterogeneity in output, employment, capital equipment, capital structures, and productivity growth rates across establishments.

7. The magnitude of within-sector heterogeneity implies that idiosyncratic factors dominate the determination of which establishments create and destroy jobs and which establishments achieve rapid productivity growth or suffer productivity declines. An examination of the literature suggests that the following may account for establishment-level heterogeneity: uncertainty; establishment-level differences in managerial ability, capital vintage, location and disturbances; and diffusion of knowledge. Starting with the first of these, one likely reason for heterogeneity in establishment-level outcomes is the considerable uncertainty that surrounds the development, adoption, distribution, marketing and regulation of new products and production techniques. Uncertainty about the demand for new products or the cost-effectiveness of alternative technologies encourages firms to experiment with different technologies, goods and production facilities (Roberts and Weitzman, 1981). Experimentation, in turn, generates differences in outcomes (Jovanovic, 1982; and Ericson and Pakes, 1989). Even when incentives for

experimentation are absent, uncertainty about future cost or demand conditions encourages firms to differentiate their choice of current products and technology so as to optimally position themselves for possible future circumstances (Lambson, 1991).

8. Another possible reason is that differences in entrepreneurial and managerial ability lead to differences in job and productivity growth rates among firms and establishments. These differences include the ability to identify and develop new products, to organise production activity, to motivate workers, and to adapt to changing circumstances. There seems little doubt that these and other ability differences among managers generate much of the observed heterogeneity in establishment-level outcomes. Business magazines, newspapers and academic case studies (*e.g.* Dial and Murphy, 1995) regularly portray the decisions and actions of particular management teams or individuals as crucial determinants of success or failure. High levels of compensation, often heavily skewed toward various forms of incentive pay (Murphy, 1997), also suggest that senior managers play key roles in business performance, including productivity and job growth outcomes.³ A related idea is that it takes time for new businesses to learn about their abilities.

9. Other factors that drive heterogeneity in establishment-level productivity, output and input growth outcomes involve establishment - and firm-specific location and disturbances. For example, energy costs and labour costs vary across locations, and so do the timing of changes in factor costs. Cost differences induce different employment and investment decisions among otherwise similar establishments and firms. These decisions, in addition, influence the size and type of labour force and capital stock that a business carries into the future. Thus, current differences in cost and demand conditions induce contemporaneous heterogeneity in establishment-level job and productivity growth, and they also cause businesses to differentiate themselves in ways that lead to heterogeneous responses to common shocks in the future. The role of establishment-specific shocks to technology, factor costs and product demand in accounting for the pace of job reallocation has been explored in Hopenhayn (1992), Hopenhayn and Rogerson (1993), and Campbell (1997).

10. Slow diffusion of information about technology, distribution channels, marketing strategies, and consumer tastes is another important source of establishment-level heterogeneity in productivity and job growth. Nasbeth and Ray (1974) and Rogers (1983) document multi-year lags in the diffusion of knowledge about new technologies among firms producing related products. Mansfield *et al.* (1981) and Pakes and Schankerman (1984) provide evidence of long imitation and product development lags.⁴

11. Part of the differences across establishments may reflect the vintage of the installed capital.⁵ Suppose, for example, that new technology can only be adopted by new establishments. Under this view, entering technologically sophisticated establishments displace older, outmoded establishments and gross output and input flows reflect a process of creative destruction. A related idea is that it may not be the vintage of the capital but rather the vintage of the manager or the organisational structure that induces establishment-level heterogeneity (see, *e.g.* Nelson and Winter, 1982).

3. Many economic analyses attribute a key role to managerial ability in the organisation of firms and production units. Lucas (1977), for example, provides an early and influential formal treatment.

4. Knowledge diffusion plays a key role in many theories of firm-level dynamics, industrial evolution, economic growth and international trade. See, for example, Grossman and Helpman (1991); Jovanovic and Rob (1989); and Jovanovic and MacDonald (1994).

5. See Aghion and Howitt (1992); Caballero and Hammour (1994, 1996); Campbell (1997); Stein (1997); Cooley *et al.* (1996); and Chari and Hopenhayn (1991).

12. These models of establishment-level heterogeneity are closely related to the theoretical growth models emphasising the role of creative destruction. Creative destruction models of economic growth stress that the process of adopting new products and new processes inherently involves the destruction of old products and processes. Creative destruction manifests itself in many forms. An important paper that formalises these ideas is Aghion and Howitt (1992). They consider a model of endogenous growth where endogenous innovations yield creative destruction. Specifically, the creator of a new innovation gets some monopoly rents until the next innovation comes along at which point the knowledge underlying the rents becomes obsolete. The incentives for investment in R&D and thus growth are impacted by this process of creative destruction.⁶

13. An alternative but related type of creative destruction growth model mentioned above as a source of establishment-level heterogeneity is the vintage capital model. One form of these models (Caballero and Hammour, 1994; and Campbell, 1997) emphasises the potential role of entry and exit. If new technology can only be adopted by new establishments, growth occurs only via entry and exit, and this requires output and input reallocation. An alternative view is that new technology is embodied in new capital (*e.g.* Cooper, *et al.*, 1997), but that existing establishments can adopt new technology by retooling. Under this latter view, both within-establishment and between-establishment job reallocation may be induced in the retooling process. If, for example, there is skill biased technical change, the adoption of new technology through retooling will yield a change in the desired mix of skilled workers at an establishment. In addition, there may be an impact on the overall desired level of employment at the establishment.

14. In all of these creative destruction models, the reallocation of outputs and inputs across producers plays a critical role in economic growth. In these models, stifling reallocation stifles growth. It is important to emphasise, however, that there are many forces that may cause growth and the pace of reallocation to deviate from optimal outcomes. As mentioned above in the context of Aghion and Howitt (1992), a generic problem is that agents (firms, innovators, workers) do not internalise the impact of their actions on others. In an analogous manner, Caballero and Hammour (1996) emphasise that the sunkness of investment in new capital implies potential *ex post* hold-up problems that yield several harmful side effects. They explore the hold-up problem generated by worker-firm bargaining over wages after the firm's investment in specific capital.⁷ One of the interesting aspects of their analysis is that it yields predictions about the patterns of reallocation that will emerge in efficient and inefficient environments. One prediction is quite intuitive and relatively easy to evaluate: economies with efficient reallocation should exhibit simultaneous creation and destruction - observation of a long lag between an increase in destruction and creation is a sign typically that market imperfections and/or institutional factors are distorting the process.

6. Growth may be more or less than optimal since there are effects that work in opposite directions. On the one hand, appropriability and intertemporal spillover effects make growth slower than optimal. The appropriability effect derives from the fact that, in their model, research on new innovations requires skilled labour as does the production of the intermediate goods where new innovations are implemented. A fixed supply of skilled labour implies that skilled labour earns part of the returns from new innovations. The inability of the research firms to capture all of the value from the innovations reduces their incentives to conduct research. The intertemporal spillover effect derives from the fact that current and future innovators derive benefits (*i.e.* knowledge) from past innovations but do not compensate past innovators for this benefit. The fact that private research firms do not internalise the destruction of rents generated by their innovation works in the opposite direction. This business stealing effect can actually yield too high a growth rate. They also find, however, that the business stealing effect also tends to make innovations too small.

7. Indeed, Blanchard and Kremer (1997) argue that for transition economies, such hold-up problems are potentially severe enough that the restructuring process is better described as "disruptive destruction" rather than creative destruction.

15. A related point is that, even though reallocation may be vital for growth, there are clearly losers in the process. The losers include the owners of the outmoded businesses that fail as well as the displaced workers. This observation is important in its own right but also potentially related to sources of distortions in the pace of reallocation. One question is whether markets are incomplete in terms of insurance and related contingent claims - the inability of losers in this process to insure against idiosyncratic risks can be a source of distortion. Moreover, the incompleteness of markets generates pressures for institutional intervention to overcome the market limitations. Put differently, barriers to the reallocation process can emerge through a variety of interventions in product, labour, trade, and credit markets that are rationalised in terms of protecting against the potential losses to those that would be adversely affected in the reallocation process.

3. Review of existing empirical evidence

16. The theoretical literature on creative destruction as well as the underlying theories of heterogeneity characterise technological change as a noisy, complex process with considerable experimentation (in terms of entry and retooling) and failure (in terms of contraction and exit) playing integral roles. In this section, we review the evidence from the recent empirical literature that has developed in parallel with the theoretical literature. We conduct this review in two parts: first, we provide a brief review of the micro patterns of output, input and productivity growth; second, we consider the aggregate implications of these micro patterns. Our review of micro patterns is brief since we regard the results discussed in this section as well-established and there are excellent recent survey articles by Bartelsman and Doms (1997) and Caves (1997) that cover much of the same material in more detail. Moreover, it is the aggregate consequences of these micro patterns that are more open to debate and there are a number of measurement/conceptual issues that generate the variation that is found across studies on this dimension.

3.1 Brief review of key micro patterns

17. We begin our review by briefly summarising a few key patterns that have become well-established in this literature. They are:

18. *Large-scale reallocation of outputs and inputs within sectors:* The rate of within-sector reallocation of output and inputs is of great magnitude. Davis and Haltiwanger (1999) summarise much of the recent literature on gross job flows; they note that in the United States, more than one in ten jobs is created in a given year and more than one in ten jobs is destroyed every year. Similar patterns hold for many other market economies. Much of this reallocation reflects reallocation within narrowly defined sectors. For example, Davis and Haltiwanger (1999) report that across a variety of studies only about 10 per cent of reallocation reflects shifts of employment opportunities across 4-digit industries.

19. It is important to emphasise that it is not only labour that is being reallocated. There is large-scale output and capital reallocation accompanying (or perhaps in some cases substituting for) the labour reallocation. Table 1 reports tabulations from Foster *et al.* (2000) with estimates of the gross expansion and contraction rates of employment, output and capital (structures and equipment) over the 1977-87 period for US manufacturing. The rates of output and input expansion (contraction) are measured as the weighted average of the growth rates of expanding (contracting) establishments including the contribution of entering (exiting) establishments using the methodology of Davis *et al.* (1996).⁸ The pace of gross output

8. This methodology entails defining establishment-level growth rates as the change divided by the average of the base and end year variable. The advantage of this growth rate measure is that it is symmetric for

and input expansion and contraction is extremely large over the ten-year horizon. Expanding establishments yielded a gross rate of expansion of more than 40 per cent of outputs and inputs and contracting establishments yielded a gross rate of contraction in excess of 30 per cent of outputs and inputs. Net growth rate of output is higher than that of inputs (especially employment) reflecting the productivity growth over this period. A large fraction of the output and input gross creation from expanding establishments came from entry and a large fraction of the output and input gross destruction came from exit.

20. Table 1 also includes the fraction of excess reallocation within 4-digit industries in each of these industries. Excess reallocation is the sum of gross expansion and contraction rates less the absolute value of net change for the sector. Thus, excess reallocation reflects the gross reallocation (expansion plus contraction) that is in excess of that required to accommodate the net expansion of the sector. Following Davis *et al.* (1996) (see pages 52 and 53 for a description of the methodology) excess reallocation rates at the total manufacturing level can be decomposed into within and between-sector effects. The far right column of Table 1 indicates that most of the excess reallocation at the total manufacturing level reflects excess reallocation within 4-digit industries. Thus, the implied large shifts in the allocation of employment, output and capital are primarily among producers in the same 4-digit industry.

21. *Entry and exit play a significant role in this process of reallocation.* For annual changes, Davis *et al.* (1996) report that about 20 per cent of job destruction and 15 per cent of job creation is accounted for by entry and exit. For five-year changes, Baldwin *et al.* (1995) report that about 40 per cent of creation and destruction are accounted for by entry and exit, respectively.⁹

22. *Persistent differences in levels of productivity.* There are large and persistent differences in productivity across establishments in the same industry (see Bartelsman and Doms, 1997) for an excellent discussion). The differences themselves are large - for total factor productivity the ratio of the productivity level for the plant at the 75th percentile to the plant at the 5th percentile in the same industry is 2.4 (this is the average across industries) - the equivalent ratio for labour productivity is 3.5. In analysing persistence, many studies report transition matrices of establishments in the relative productivity distribution within narrowly defined industries (see, *e.g.* Baily *et al.*, 1992; and Bartelsman and Dhrymes, 1994). These transition matrices exhibit large diagonal and near-diagonal elements indicating that establishments that are high in the distribution in one period tend to stay high in the distribution in subsequent periods. In contrast, establishment-level productivity growth *rates* exhibit an important transitory component. Baily *et al.* (1992) and Dwyer (1995) present strong evidence of regression to the mean effects in productivity growth regressions.

23. *Low productivity helps predict exit:* Many studies (*e.g.* Baily *et al.*, 1992; Olley and Pakes, 1996; and Dwyer, 1995) find that the productivity level helps predict exit. Low productivity establishments are more likely to exit even after controlling for other factors such as establishment size and age. A related set of findings is that observable establishment characteristics are positively correlated with productivity including size, age, wages, adoption of advanced technologies, and exporting (see, *e.g.* Baily *et al.*, 1992; Doms *et al.*, 1996; Olley and Pakes, 1996; and Bernard and Jensen, 1995). It has been more difficult to find correlates of changes in productivity. For example, Doms *et al.* (1996) find that establishments that

positive and negative changes and allows for an integrated treatment of entering and exiting establishments.

9. The calculations in Baldwin *et al.* (1995) are an updated version of earlier calculations by Dunne *et al.* (1989). The five-year gross flows and the shares accounted for by entry and exit are somewhat lower in the later work for equivalent periods reflecting the improvement in longitudinal linkages in the Census of Manufacturers over time.

have adopted advanced technologies are more likely to be high productivity establishments but that the change in productivity is only weakly related to the adoption of such advanced technologies.

3.2 Reallocation and aggregate productivity growth

24. Empirical analysis of the implications of the pace of reallocation and restructuring for productivity dynamics has been recently provided by Baily *et al.* (1992), Olley and Pakes (1996), Bartelsman and Dhrymes (1994), Dwyer (1995, 1997), Haltiwanger (1997), and Foster *et al.* (2000) using establishment-level manufacturing data from the United States; Aw *et al.* (1997) using firm-level data from Taiwan; Tybout (1996) and Liu and Tybout (1996) using data from Columbia, Chile, and Morocco; and Griliches and Regev (1995) using data from Israel.¹⁰ Virtually all of the studies consider some form of decomposition of an index of industry-level productivity:

$$P_{it} = \sum_{e \in I} s_{et} p_{et} \quad [1]$$

here P_{it} is the index of industry productivity, s_{et} is the share of establishment e in industry i (e.g. output share), and p_{et} is an index of establishment-level productivity.

3.2.1 Measurement methodology

25. The results that one obtains from decomposing [1] do turn out to be sensitive on some dimensions to measurement methodology. To illustrate the sensitivity to measurement methodology, two alternative decomposition methodologies are considered. The first decomposition method (denoted method 1 in what follows) considered is a modified version of that used by Baily *et al.* (1992) and is given by:¹¹

$$\begin{aligned} \Delta P_{it} = & \sum_{e \in C} s_{etl} \Delta p_{et} + \sum_{e \in C} (p_{etl} P_{itl}) \Delta s_{et} + \sum_{e \in C} \Delta p_{et} \Delta s_{et} \\ & + \sum_{e \in N} s_{et} (p_{et} P_{itl}) \sum_{e \in X} s_{etl} (p_{etl} P_{itl}) \end{aligned} \quad [2]$$

where C denotes continuing establishments, N denotes entering establishments, and X denotes exiting establishments. The first term in this decomposition represents a within-establishment component based on establishment-level changes, weighted by initial shares in the industry. The second term represents a between-establishment component that reflects changing shares, weighted by the deviation of initial establishment productivity from the initial industry index. The third term represents a cross

10. Baldwin (1995) presents some related analysis of the contribution of establishment turnover to productivity growth for Canada but his methodology differs sufficiently from the rest of the literature that it is not easy to integrate his work into this discussion.

11. The first term in this decomposition (the “within component”) is identical to that in Baily *et al.* (1992). They essentially combined the second two terms by calculating a term based upon the sum of changes in shares of activity weighted by ending period productivity. In addition, they did not deviate the terms in the between and net entry terms from initial levels. As Haltiwanger (1997) points out, this implies that even if all establishments have the same productivity in both beginning and end periods, the between component and the net entry component in the Baily *et al.* (1992) decomposition will, in general, be non-zero. See Haltiwanger (1997) for further discussion.

(i.e. covariance-type) term. The last two terms represent the contribution of entering and exiting establishments, respectively.

26. In this decomposition, the between-establishment term and the entry and exit terms involve deviations of establishment-level productivity from the initial industry index. For a continuing establishment, this implies that an increase in its share contributes positively to the between-establishment component only if the establishment has higher productivity than average initial productivity for the industry. Similarly, an exiting establishment contributes positively only if the establishment exhibits productivity lower than the initial average, and an entering establishment contributes positively only if the establishment has higher productivity than the initial average.

27. This decomposition differs somewhat from others that have appeared in the literature in some subtle but important ways. Key distinguishing features of the decomposition used here are: *i*) an integrated treatment of entry/exit and continuing establishments; *ii*) separating out within and between effects from cross/covariance effects. Some of the decompositions that appear in the literature are more difficult to interpret because they do not separate out cross/covariance effects. For example, some measure the within effect as the change in productivity weighted by average shares (in t and $t-k$ - see method 2 below). While the latter method yields a seemingly cleaner decomposition, it also allows the within effect to partially reflect reallocation effects since it incorporates the share in period t . Another problem is in the treatment of net entry. Some of the decompositions in the literature that consider net entry measure the contribution of net entry via the simple difference between the weighted average of entrants and exiting establishments productivity. Even if there are no differences in productivity between entering and exiting establishments, this method yields the inference that net entry contributes positively to an increase (decrease) in productivity growth if the share of entrants is greater (less than) the share of exiting establishments. There are related (and offsetting) problems in the treatment of the contribution of continuing establishments.

28. While this first method is our preferred decomposition, it is worthwhile to consider an alternative decomposition closely related to that used by Griliches and Regev (1995). Consider, in particular, the following alternative decomposition (denoted method 2 in the remainder of this paper):

$$\begin{aligned} \Delta P_{it} = & \sum_{e \in C} s_e \overline{\Delta p_{et}} + \sum_{e \in C} (\overline{p_e P_i}) \Delta s_{et} \\ & + \sum_{e \in N} s_{et} (\overline{p_{et} P_i}) - \sum_{e \in X} s_{et} (\overline{p_{et} P_i}) \end{aligned} \quad [3]$$

where a bar over a variable indicates the average of the variable over the base and end year. In this decomposition, the first term is interpretable as a within effect that is measured as the weighted sum of productivity with the weights equal to the average (across time) shares. The second is interpretable as a between effect where the changes in the shares are indexed by the deviations of the average establishment level productivity from the overall industry average. In a like manner, the net entry terms are such that entry contributes positively as long as entering establishments are higher than the overall average and exiting establishments are lower than the overall average.

29. This second decomposition method is a modification of the standard within/between decomposition that is often used for balanced panels. The disadvantage of this method is that the measured within effect will now reflect in part cross/covariance effects (as will the measured between effect). However, this second method is apt to be less sensitive to measurement error in outputs or inputs relative to the first method as shown in equation [2]. Suppose, for example, we are considering labour productivity (e.g. output per man-hour) and that there is random measurement error in measured man-hours. Measurement error of this type will imply that establishments in a given period with spuriously high measured man-hours will have spuriously low measured productivity. Such measurement error will yield a

negative covariance between changes in productivity and changes in shares (measured in terms of man-hours) and a spuriously high within-establishment effect under method 1. In a similar manner, consider the decomposition of multi-factor productivity using output weights. Random measurement error in output will yield a positive covariance between productivity changes and changes in shares and a spuriously low within-establishment effect under method 1. In contrast, the measured within effect from method 2 will be less sensitive to random measurement error in output or inputs since the averaging across time of the shares will mitigate the influence of measurement error.¹²

30. Which method should be preferred? Absent measurement error, method 1 is clearly the preferred method since it offers more detail and all of the terms are readily interpretable (there is not a confounding of reallocation and within effects in the “within” term). Nevertheless, concerns about measurement error are non-trivial. The latter concerns are likely to be especially of concern for analyses using high frequency data where output and employment growth rates are apt to be especially noisy.

31. In reviewing evidence in the next section, we restrict ourselves to comparing the components of the evidence that use sufficiently similar methodology to permit a reasonable comparison. As will become clear, this implies that for many studies we do not have and cannot compare all of the terms in the above decompositions.

3.2.2 *The evidence*

32. Using establishment-level data, the industry index and its components can be constructed for measures of labour and multi-factor productivity. Many studies have used something analogous to one of the methodologies above to decompose the time series changes in aggregate (*i.e.* industry-level) productivity into components that reflect a within component (holding shares fixed in some manner) and other effects that reflect the reallocation of the shares across establishments including the impact of entry and exit. Table 2 presents a summary of results from a variety of studies using different countries, time periods, frequency of measured changes, productivity concepts (*i.e.* multi-factor *vs.* labour) and measurement methodologies (see the discussion in the prior subsection).¹³ The differences along these many dimensions make fine comparisons difficult so the objective in considering the alternative studies is to consider broad patterns. In the next section, some of these methodological issues are considered in more detail. For now, an attempt is made to compare studies on dimensions that are relatively easy to compare.

33. One core aspect that is roughly comparable across studies is the contribution of the within establishment contribution to aggregate productivity growth. Even for this measure, there are differences in the methodology along a number of dimensions. These include whether the measure of productivity is multi-factor or labour, whether the share is based on output or employment weights, and whether the share is based on the initial share at the base period or the average share (averaged over base and end period). The latter difference often reflects a study using method 1 *vs.* method 2 in the analysis.

34. The fraction of within-establishment contribution to multi-factor productivity growth ranges from 0.23 to 1.00 across studies, while the fraction of the within-establishment contribution to labour productivity growth ranges from 0.79 to 1.20 across studies. At first glance, it appears to be difficult to draw conclusions even in broad terms about whether the within-establishment contribution is large or

12. This discussion focuses on simple classical measurement error. There may be other forms of non-random measurement error that are important in this context.

13. In the case of Taiwan, a simple average (or simple median) of the industry-level results reported in the Aw *et al.* (1997) paper is presented.

small. However, careful examination of the individual studies indicates that this variation is due in part to there being systematic sensitivity to time period, frequency, and differences between the consequences of output vs. labour reallocation.

35. Another dimension that many of the studies are comparable is the contribution of net entry to productivity growth. The results here range from 0.25 to 0.26 for multi-factor productivity and from 0.02 to 1.00 for studies of labour productivity. Again, it would first appear that it would be difficult to draw strong conclusions. Moreover, since the within plus the net entry components for some cases sum to greater than one, this implies the reallocation among the continuing establishments is in those cases working in the opposite direction. As we shall see, like for the within-establishment effect, the net entry effect differences across studies reflect some systematic patterns.

36. We begin by considering the contribution of establishment entry and exit to these aggregate productivity dynamics. From Table 2, we see that one important factor is the horizon over which the productivity growth is measured. By construction, the share of activity accounted for by exits in the base year and entrants in the end year are increasing in the horizon over which the base and end year are measured. At an annual frequency, we observe that the share of employment accounted for by exits in the United States in the year $t-1$ is only 0.02 and by entrants in year t is only 0.01. In contrast, at a ten-year horizon, the share of employment accounted for by establishments in the United States in year $t-10$ that ultimately exit over the ten years is 0.28 while the share of employment accounted for by establishments in year t that entered over the ten years is 0.26. These results imply that the contribution of any differences in productivity between entering and exiting establishments will be greater for changes measured over a longer horizon.

37. The influence of the horizon also is likely to impact the observed productivity differences between exiting establishments in the base year and entering establishments in the end year via selection and learning effects. That is, one-year-old establishments are likely to have on average a lower productivity than ten-year-old establishments because of selection and learning effects. Many studies (*e.g.* Olley and Pakes, 1996; Liu and Tybout, 1996; Aw *et al.*, 1997; Foster *et al.*, 2000) present results suggesting that selection and learning effects play an important role. The results in Table 2 reflect this in that the relative productivity of entering establishments in the end-year to exiting establishments in the base year is increasing for changes measured over a longer horizon.¹⁴

38. Putting these results on entry and exit together helps account for the finding that studies that focus on high frequency variation (*e.g.* Baily *et al.*, 1997; and Griliches and Regev, 1995) tend to find a small contribution of net entry to aggregate productivity growth while studies over a longer horizon find a large role for net entry (*e.g.* Baily *et al.*, 1996; Haltiwanger, 1997; Foster *et al.*, 2000; and Aw *et al.*, 1997). There are two main factors that contribute to this sensitivity to frequency: *i*) entering and exiting businesses at high frequencies account for a small share of activity while entering and exiting businesses at lower frequencies account for a non-trivial share of activity; *ii*) entering businesses enter at higher productivity than exiting businesses but selection/learning effects imply that the productivity gap at the point of simultaneous exit/entry is small but grows over time.

39. Now consider the sensitivity to business cycles. Table 3 presents a few selected results from different time periods from the Baily *et al.*, (1992) and Foster *et al.* (2000) studies. For the 1977-82 and 1987-92 periods, the within-establishment contribution for manufacturing in general is negative for both studies reflecting the fact that, while there is modest overall productivity growth over this period, its source

14. Although the earlier vintage arguments suggest that it may be that younger establishments should have higher productivity. While such vintage effects may be present, the evidence clearly suggests that the impact of selection and learning effects dominate.

is not the within-establishment component. In contrast, for the 1982-87 period the within-establishment contribution is large and positive during a period of robust productivity growth. This apparent sensitivity to the business cycle (1982 was during a severe slump in US manufacturing) is interesting in its own right. These results suggest that overall productivity is less procyclical than within-establishment productivity. The inference is that reallocation effects tend to generate a counter-cyclical “bias” and thus recessions are times that the share of activity accounted for by less productive establishments decreases either through contraction or exit. Baily *et al.* (1997) provide a more extensive analysis of the role of reallocation for the cyclical behaviour of productivity and present considerable evidence that the within-establishment component of aggregate productivity is more procyclical than the aggregate itself.

40. Now consider the differences between the results decomposing labour productivity and multi-factor productivity. For the contribution of net entry, the decompositions of multi-factor and labour productivity have very similar findings. For the contribution of within establishment, the decompositions are very different. The reason for these differences in the respective contributions to the total depends in part on the role of reallocation *among continuing establishments*. That is, output reallocation across continuing establishments is positively correlated with multi-factor productivity growth but labour reallocation across continuing establishments is weakly or even negatively correlated with labour productivity growth. Foster *et al.* (2000) show that for continuing establishments there are strong positive correlations between output growth and employment growth, between multi-factor and labour productivity growth, and between multi-factor productivity growth and output growth. However, there is a zero or sometimes even a strong negative correlation for continuing establishments between labour productivity growth and employment growth.

41. These results show that it is inappropriate to infer that all or even most job reallocation reflects the movement of employment from less productive to more productive businesses. Instead, employment downsizing often accompanies large productivity gains. For example, as described in Davis and Haltiwanger (1999), the US steel industry underwent tremendous restructuring during the 1970s and 1980s. Much of this restructuring involved a shift from large, integrated mills to more specialised mini mills. Entry and exit played a major role, but the restructuring of the industry also involved the retooling of many continuing establishments. The employment-weighted mean number of workers at US steel mills fell from 7000 in 1980 to 4000 in 1985. Baily *et al.* (1996) find that continuing establishments in the steel industry experienced substantial productivity gains while downsizing. Moreover, the downsizing episode in the early 1980s was followed by dramatic productivity gains in the steel industry in later years (see, Davis *et al.*, 1996).

42. It is useful to compare and contrast the results on the reallocation involving net entry with those involving reallocation across continuing establishments. With entry and exit, labour and output (and capital) reallocation go hand-in-hand. Exit is clearly a sign of poor performance and both low labour productivity and low multi-factor productivity help predict exit. However, the same is not the case for output and labour reallocation across continuing establishments. Indeed, Foster *et al.* (2000) find that the correlation between labour productivity growth and increases in capital intensity to be quite large for continuing establishments. Thus, observing that a business is downsizing in terms of workers does not inherently imply a sign of distress but may reflect a restructuring involving increasing capital intensity (and perhaps skill intensity as suggested in the analysis of Dunne *et al.*, 1997) with associated increases in labour productivity.

43. To summarise the main points from the evidence on the contribution of reallocation to aggregate productivity growth and fluctuations:

- The contribution of net entry to aggregate productivity growth is disproportionate and increases over the horizon for which the change is being measured. The latter effect reflects both increasing shares of entry/exit over longer horizons and learning/selection effects.
- Output reallocation among continuing establishments contributes positively to aggregate multi-factor and labour productivity growth. Labour reallocation among continuing establishments, while correlated with output reallocation, does not contribute positively to labour productivity growth as downsizing of a continuing business is often associated with rising labour productivity. Labour reallocation from net entry does contribute positively to labour productivity growth.
- Reallocation yields a counter-cyclical “bias” to measured fluctuations in aggregate productivity growth at high frequencies. Put differently, the average continuing establishment exhibits even greater procyclicality in productivity than would be suspected from the aggregate data.

4. Caveats, questions and issues

44. The general theme thus far is that growth is a noisy process with much trial and error. Economic growth inherently involves a continuous pace of restructuring and reallocation as businesses try out new techniques, new products, and new locations and adapt to a continuously changing environment. The resulting churning of businesses and outputs and inputs is large - moreover this churning contributes significantly to growth. The policy implications at first glance appear clear - create a market environment where successful innovators can indeed succeed and unsuccessful businesses can fail.

45. The problem is that market imperfections (and in turn market institutions) may yield inefficiencies in this process of reallocation. As discussed in section II and emphasised by Caballero and Hammour (2000), the continuous process of reallocation has many potential pitfalls. The largest problem is that reallocation involves businesses between themselves and with workers engaging in a variety of relationships with a high degree of *specificity*. By specificity, we mean that some of the joint value of a relationship is specific to that particular relationship and would be lost if the parties terminated their relationship. The specific investments that firms and workers make in creating jobs and making matches are some of the factors that yield such specificity. The problem with such relationships is that there is an *ex post* hold-up problem and the question is whether the market structure and institutions yield an efficient solution to the hold-up problem.

46. Caballero and Hammour (2000) argue that various countries and parts of the world have experienced problems in the institutional and market structure along these lines with significant adverse aggregate consequences. For example, many post-communist countries have seen their potential for growth and restructuring stifled by an underdeveloped legal and institutional environment. In Western Europe, labour-market regulation stifles this reallocation process. The crises in emerging markets can be attributed to economic systems with a lack of transparency and lax corporate governance standards. In all of these cases, the limitations of the institutional/market structure stifle and distort the ongoing reallocation process (and thus the ability to tap new technological developments and to adapt to a changing environment).

47. Analysis and evidence of the efficiency aspects of the reallocation process are still in their infancy. Davis and Haltiwanger (1999), Hopenhyn and Rogerson (1993), and Mortensen (1994) provide calibrations/simulations of the distortions in the magnitude of reallocation that can occur from various labour-market interventions. As noted in Section II, one indicator of efficiency that Caballero and Hammour (1996, 2000) emphasise is the presence of synchronised creation and destruction. The evidence

for the United States suggests high rates of creation and destruction in the same period regardless of industry/time period with most workers involved in the reallocation process experiencing direct job-to-job movements - both of the features are suggestive of an efficient environment. However, over the course of a business cycle, the United States exhibits sharp spikes in job destruction in recessions followed by long and slow recoveries involving an increase in job creation. The staggered nature of creation/destruction at business cycle frequencies is a potential sign of inefficiency even for the United States. For other western economies, Davis and Haltiwanger (1999) survey the evidence on job creation/destruction. In their Figure 3.5, they show patterns of annual creation and destruction rates for eight countries. All of the countries exhibit creation and destruction being inversely correlated and a surge of destruction leading more gradual increases in creation over the course of several years.

48. Haltiwanger and Vodopivec (2000) provide some evidence on synchronisation/staggering of creation/destruction for transition economies. They compare and contrast the job and worker flows for a rapid reformer, Estonia, and a gradual reformer, Slovenia. Estonia made dramatic changes to open up product, labour, credit and trade markets quickly. For example, in terms of the labour market, they eliminated firing restrictions, established a very modest UI system, and allowed for decentralised wage determination with a very low minimum wage. In contrast, Slovenia retained restrictions of firing, established a quite generous UI system, and virtually all wages are determined via collective bargaining with a high minimum wage. Estonia experienced a surge in job flows from around zero in 1990 to almost 10 per cent creation and destruction rates by 1995 (similar to U.S. rates). Moreover, while destruction led creation and 1992 and 1993 were very difficult years in terms of a sharp downturn in aggregate activity, the increase in flows was relatively synchronised as evidenced by a dramatic surge in job to job movements for workers experiencing job destruction. In contrast, in Slovenia the magnitude of the creation/destruction flows has remained substantially less in Slovenia and destruction has led creation by a substantial period. Interestingly, both of these economies have done reasonably well in terms of recovering from the downturn in aggregate activity associated with the transition. Also, interestingly, Estonia has experienced a sharper downturn and a much sharper upturn than Slovenia.

49. Overall, we are still in the early stages of the development of the theory, the appropriate empirical specifications and the requisite data for the micro restructuring/reallocation approach towards understanding economic growth. Limited data development is a major obstacle for understanding these issues because the requisite data are measures of output and input reallocation (including the contribution of entry/exit) linked to unemployment/worker flows and in turn linked to measures of business performance. That is, to investigate these issues we need measures of the churning and to be able to relate these to worker and firm outcomes. Very few countries have developed the data that would permit this type of analysis. We need to develop such data so that both within-country studies and cross-country comparisons become feasible. With such data a variety of open questions could be investigated including: quantifying the magnitude and timing of reallocation, analysing the connection between the pace and timing of reallocation with market and institutional structure, and analysing the connection between the pace and timing of reallocation and key macro outcomes like output, consumption, employment and productivity growth. Putting together the requisite data for within-country and cross-country study of these issues should be a high priority.

5. Concluding remarks

50. In this study we have focused on the contribution of the reallocation of activity across individual producers in accounting for aggregate productivity growth. A growing body of empirical analysis reveals striking patterns in the behaviour of establishment-level reallocation and productivity. First, there is a large ongoing pace of reallocation of outputs and inputs across establishments in market economies. Second, the pace of reallocation varies secularly, cyclically and by industry. Third, there are large and persistent

productivity differentials across establishments in the same industry even in well functioning market economies. Fourth, entering establishments tend to have higher productivity than exiting establishments. Large productivity differentials and substantial reallocation are the necessary ingredients for an important role for reallocation in aggregate productivity growth. The emerging evidence suggests that the process of economic growth at the micro level is incredibly noisy and complex - there is a vast amount of churning as businesses and workers seek to find the best methods, products, locations and matches. This churning is an inevitable and vital component of economic growth. However, a number of conceptual and measurement issues remain. We don't have a clear understanding of the sources of within and between-country variation in the nature and magnitude of this churning, we don't have a clear understanding of the sources of within-industry heterogeneity in productivity levels and growth rates, and in turn we don't have a clear understanding of all of this variation for within and between-country outcomes like economic growth. A key obstacle for current work is that the requisite data development is still in early stages.

Table 1a. Gross reallocation of employment, output, equipment and structures

Ten-year changes from 1977-87 for U.S. manufacturing

Measure	Creation (expansion) rate	Share of creation (expansion) due to entrants	Destruction (contraction) rate	Share of destruction (contraction) due to exits	Fraction of excess reallocation within 4-digit industry
Real gross output	49.4	0.44	34.4	0.61	0.80
Employment	39.4	0.58	45.8	0.62	0.75
Capital equipment	46.1	0.42	37.1	0.51	0.71
Capital structures	44.9	0.44	48.4	0.42	0.69

Table 1b. Gross reallocation of employment and output for automobile repair shops**Panel A: Five-year changes from 1987-92, employment**

Real gross output	51.8	0.76	40.3	0.62	0.81
Employment	50.9	0.76	44.2	0.64	0.88

Notes: See text for details of construction of output, equipment and structures measures.

Source: Foster *et al.* (2000).

Table 2. A comparison of decompositions of aggregate productivity growth**A. Multi-factor productivity decompositions**

Country	Frequency	Sample period	Sectoral coverage	Weight used to calculate within establishment changes ¹	Average fraction from within establishment changes	Fraction of activity ² from entrants (t)	Fraction of activity from exits (t-k)	Relative productivity of births (t) to deaths (t-k)	Average fraction from net entry	Study
United States	5-year	1972-87	Selected mfg industries (23)	Output (t-k)	0.37	N/A	N/A	N/A	N/A	Baily, Hulten and Campbell (1992)
United States	5-year	1977-92	All mfg industries	Output (t-k)	0.12	N/A	N/A	N/A	0.25	Foster, Haltiwanger, and Krizan (2000)
United States	10-year	1977-87	All mfg industries	Output (t-k)	0.48	0.21	0.22	1.14	0.26	Foster, Haltiwanger, and Krizan (2000)
Taiwan ³	5-year	1981-91	Selected mfg industries (9)	Output (avg. of (t-k) and t)	0.94 (Median = 0.63)	N/A	N/A	N/A	N/A	Aw, Chen and Roberts (1997)
Columbia	Annual	1978-86	Selected mg industries (5)	Input Index ⁴ (avg of (t-k) and t)	1.00	N/A	0.05	1.05	N/A	Liu and Tybout (1996)

Table 2 (continued)

B. Labour productivity growth decompositions

Country	Frequency	Sample period	Sectoral coverage	Weight used to calculate within establishment changes	Average fraction from within establishment changes	Fraction of activity from entrants (t)	Fraction of activity from exits (t-k)	Relative productivity of births (t) to deaths (t-k)	Average fraction from net entry	Study
United States	5-year	1977-92	All mfg. Industries	Man-hours (t-k)	1.00	N/A	N/A	N/A	0.20	Foster, Haltiwanger, and Krizan (2000)
United States	5-year	1987-92	Selected service sector industries	Employment (t-k)	0.99	0.32	0.39	1.11	1.12	Foster, Haltiwanger, and Krizan (2000)
United States	10-year	1977-87	All mfg. Industries	Employment (t-k)	0.77	0.21	0.25	1.34	0.31	Foster, Haltiwanger, and Krizan (2000)
United States	Annual	1972-88	All mfg. Industries	Man-hours (t-k)	1.20	0.01	0.02	1.03	0.02	Baily, Bartelsman and Haltiwanger (1997)
Israel	3-year	1979-88	All mfg. Industries	Employment (avg of (t-k) and t)	0.83	0.08	0.06	1.20		Griliches and Regev (1995)

1. Within contribution is measured as the weighted sum of establishment-level productivity growth as a fraction of aggregate index of productivity growth. In all cases, output above refers to gross output.
2. Activity is measured in the same units as weight (e.g. employment or output).
3. Simple average (and simple median) of industry-based results reported.
4. The input index is a geometric mean of inputs using estimated factor elasticities.

Table 3. Sensitivity of decomposition results to business cycle and sector

Five-year frequency							
	1977-1982		1982-1987		1987-92		
Sectoral coverage	Multi-factor productivity growth	Fraction from within establishment changes	Multi-factor productivity growth	Fraction from within establishment changes	Multi-factor productivity growth	Fraction from within establishment changes	Study
All mfg industries	2.43	-0.12	8.26	0.58	3.30	-.06	Foster, Haltiwanger, and Krizan (2000)
Selected mfg industries (23)	2.39	-0.46	15.63	0.87	N/A	N/A	Baily, Hulten and Campbell (1992)

Notes: Weight for within calculation from both studies is initial gross output share for the establishment in each industry. Results aggregated across industries are based upon weighted average with weight for this purpose equal to the average of nominal gross output for the industry.

BIBLIOGRAPHY

- AGHION, Philippe and Peter HOWITT (1992), "A model of growth through creative destruction", *Econometrica*, 60(2), pp. 323-351.
- AW, Bee Yan, Xiaomin CHEN and Mark J. ROBERTS (1997), "Firm-level evidence on productivity differentials, turnovers, and exports in Taiwanese manufacturing", *NBER Working Paper* No. 6235.
- BAILY, Martin Neil, Eric J. BARTELSMAN and John HALTIWANGER(1996), "Downsizing and productivity growth: myth or reality?" *Small Business Economics*, 8, pp. 259-278.
- BAILY, Martin Neil, Eric J. BARTELSMAN and John HALTIWANGER(1997), "Labor productivity: structural change and cyclical dynamics," *NBER Working Paper* No. 5503 (revised).
- BAILY, Martin Neil, Charles HULTEN and David CAMPBELL (1992), "Productivity dynamics in manufacturing establishments", *Brookings Papers on Economic Activity: Microeconomics*, pp. 187-249.
- BALDWIN, John R. (1995), "Turnover and productivity growth" in Baldwin (ed.), *The Dynamics of Industrial Competition*, Cambridge: Cambridge University Press, pp. 208-38.
- BALDWIN, John R., Tim DUNNE and John HALTIWANGER (1995), "Establishment turnover in Canada and the United States," in Baldwin (ed.), *The Dynamics of Industrial Competition*, Cambridge: Cambridge University Press, pp. 119-52.
- BARTELSMAN, Eric J. (1995), "Using microdata for economic research and policy analysis," unpublished manuscript, Central Planning Bureau, Netherlands.
- BARTELSMAN, Eric J. and Mark DOMS (1997), "Understanding productivity: lessons from longitudinal micro datasets," mimeo.
- BARTELSMAN, Eric J. and Wayne GRAY (1996), "The NBER manufacturing productivity database," *NBER Technical Working Paper* No. 205.
- BARTELSMAN, Eric J. and Phoebus J. DHRYMES (1994), "Productivity dynamics: U.S. manufacturing establishments, 1972-86," Board of Governors of the Federal Reserve Board, *Finance and Economics Discussion Series*, No. 94-1.
- BERNARD, Andrew B. and J. Bradford JENSEN (1995), "Exceptional exporter performance: cause, effects, or both?" mimeo.
- BERNDT, Ernst R. and Jack E. TRIPLETT (eds.), "Fifty years of economic measurement", *Studies in Income and Wealth*, Vol. 54, Chicago: The University of Chicago Press.

- BLANCHARD, Olivier and Michael KREMER (1997), "Disorganization", *Quarterly Journal of Economics*.
- CABALLERO, Ricardo and Mohamad HAMMOUR (1994), "The cleansing effects of recessions," *American Economic Review*, 84(5), pp. 1356-68.
- CABALLERO, Ricardo and Mohamad HAMMOUR (1996), "On the timing and efficiency of creative destruction," *Quarterly Journal of Economics*, 111(3), pp. 805-852.
- CABALLERO, Ricardo and Mohamad HAMMOUR (2000), "Institutions, restructuring, and macroeconomic performance," *NBER Working Paper No. 7720* (May).
- CAMPBELL, Jeffrey R (1997), "Entry, exit, technology, and business cycles", *NBER Working Paper No. 5955*.
- CAVES, Richard E (1997), "Industrial organization and new findings on the turnover and mobility of firms", *Working Paper*, Harvard University.
- CHARI, V.V. and Hugo HOPENHAYN (1991), "Vintage human capital, growth, and the diffusion of new technology," *Journal of Political Economy*, 99 (6), pp. 1142-65.
- COOLEY, T., J. GREENWOOD and M. YORUKOGLU (1996), "The replacement problem", *Working Paper*, University of Rochester.
- COOPER, Russell, John HALTIWANGER and Laura POWER (1997), "Machine replacement and the business cycle: lumps and bumps", *NBER Working Paper No. 5260* (revised).
- DAVIS, Steven J. and John HALTIWANGER (1991), "Wage dispersion between and within U.S. manufacturing establishments, 1963-86", *Brookings Papers on Economic Activity, Microeconomics*, pp. 115-20.
- DAVIS, Steven J. and John HALTIWANGER (1999), "Gross job flows", in ASHENFELTER and CARD (eds.), *Handbook of Labor Economics*, North-Holland, pp. 2711-2805.
- DAVIS, Steven J., John HALTIWANGER and Scott SCHUH (1996), *Job Creation and Destruction*, Cambridge: MIT Press.
- DEAN, Edwin R. and Kent KUNZE (1992), "Productivity measurement in service industries", in *Output Measurement in the Service Sector*, Chicago: University of Chicago Press for NBER, pp. 73-101.
- DIAL, Jay and Kevin J. MURPHY (1995), "Incentives, downsizing, and value creation at general dynamics," *Journal of Financial Economics*, 37, pp. 261-314.
- DOMS, Mark and Timothy DUNNE (1994), "Capital adjustment patterns in manufacturing establishments", *Center for Economic Studies Working Paper*, CES 94-11.
- DOMS, Mark, Timothy DUNNE and Kenneth TROSKE (1996), "Workers, wages, and technology", *Quarterly Journal of Economics*, 112, pp. 253-90.
- DWYER, Douglas (1995), "Technology locks, creative destruction, and non-convergence in productivity levels", *Center for Economic Studies Working Paper*, CES 95-6.

- DWYER, Douglas (1997), "Productivity races I: are some productivity measures better than others?", *Center for Economic Studies Working Paper, CES 97-2*.
- DUNNE, Timothy, Mark ROBERTS and Larry SAMUELSON (1989), "Establishment turnover and gross employment flows in the U.S. manufacturing sector," *Journal of Labor Economics*, 7(1), pp. 48-71.
- ERICSON, Richard and Ariel PAKES (1989), "An alternative theory of firm and industry dynamics", *Discussion Paper 445*, Columbia University (September).
- ERICSON, Richard and Ariel PAKES (1995), "Markov-perfect industry dynamics: a framework for empirical work", *Review of Economic Studies*, 62(1) pp. 53-82.
- FOSTER, Lucia, John HALTIWANGER and C.J. KRIZAN (1998), "Aggregate productivity growth: lessons from microeconomic evidence", *NBER Working Paper No. 6803* (mimeo., revised June 2000).
- GRILICHES, Zvi (1994), "Productivity, R&D, and the data constraint", *American Economic Review*, 84(1), pp. 1-23.
- GRILICHES, Zvi (ed.) (1992), "Output measurement in the service sectors", *Studies in Income and Wealth*, Vol. 56, Chicago: The University of Chicago Press.
- GRILICHES, Zvi and Haim REGEV (1995), "Productivity and firm turnover in Israeli industry: 1979-1988", *Journal of Econometrics*, 65, pp. 175-203.
- GROSSMAN, Gene M. and Elhanan HELPMAN (1991), *Innovation and Growth in the Global Economy*, Cambridge: MIT Press.
- HALTIWANGER, John (1997), "Measuring and analyzing aggregate fluctuations: the importance of building from microeconomic evidence", *Federal Reserve Bank of St. Louis Economic Review*, January/February.
- HALTIWANGER, John and Milan VODOPIVEC (2000), "Gross worker and job flows in a transition economy: an analysis of Estonia", mimeo. (June).
- HOPENHYN, Hugo (1992), "Entry, exit, and firm dynamics in long run equilibrium", *Econometrica*, 60(5), pp. 1127-50.
- HOPENHYN, Hugo and Richard ROGERSON (1993), "Job turnover and policy evaluation: a general equilibrium approach", *Journal of Political Economy*, 101(5), pp. 915-38.
- JOVANOVIC, Boyan (1982), "Selection and the evolution of industry," *Econometrica*, 50(3), pp. 649-70.
- JOVANOVIC, Boyan and Glenn M. MacDONALD (1994), "Competitive diffusion", *Journal of Political Economy*, 102 (1) pp. 24-52.
- JOVANOVIC, Boyan and Rafael ROB (1989), "The growth and diffusion of knowledge", *Review of Economic Studies*, 56, pp. 569-82.
- KENDRICK, John W. and Beatrice N. VACCARA (eds.) (1980), "New developments in productivity and measurement analysis, *Studies in Income and Wealth*, Vol. 44, Chicago: The University of Chicago Press.

- LAMBSON, Val E. (1991), "Industry evolution with sunk costs and uncertain market conditions", *International Journal of Industrial Organization*, 9(2), pp. 171-96.
- LIU, Lili and James R. TYBOUT (1996), "Productivity growth in Chile and Columbia: the role of entry, exit and learning", in ROBERTS and TYBOUT (eds.), *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure*, New York: Oxford University Press for the World Bank, pp. 73-103.
- LUCAS, Robert E. (1977), "On the size distribution of business firms", *Bell Journal of Economics*, 9(Autumn), pp. 508-23.
- MANSFIELD, Edwin, Mark SCHWARTZ and Samuel WAGNER (1981), "Imitation costs and patents", *Economic Journal*, 91, p. 907-918.
- McGUCKIN, Robert H (1995), "Establishment microdata for economic research and policy analysis: looking beyond the aggregates", *Journal of Economics and Business Statistics*, 13(1), pp. 121-6.
- MURPHY, Kevin J (1997), "Pay, performance, and executive compensation", in ASHENFELTER and CARD (eds.), *Handbook of Labor Economics*.
- NASBETH, Lars and George RAY (eds.) (1974), *The Diffusion of New Industrial Processes: An International Study*, Cambridge: Cambridge University Press.
- NELSON, Richard R. and Sidney G. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.
- OLLEY, G. Steven and Ariel PAKES (1996), "The dynamics of productivity in the telecommunications equipment industry", *Econometrica*, 64(6), pp. 1263-1297.
- PAKES, Ariel and Mark SCHANKERMAN (1984), "The rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources", in GRILICHES (ed.), *R&D, Patents, and Productivity*, Chicago: University of Chicago Press for NBER.
- ROBERTS, Mark J. and Dylan SUPINA (1997), "Output price and markup dispersion in micro data: the roles of producer and heterogeneity and noise," *Center for Economic Studies Discussion Paper*, CES 97-10.
- ROBERTS, Kevin and Martin L. WEITZMAN (1981), "Funding criteria for research, development, and exploration projects", *Econometrica*, 39, pp. 1261-88.
- ROGERS, Everett M (1983), *Diffusion of Innovations* (3rd ed.), New York: Free Press.
- SCHUMPETER, J.A. (1942), *Capitalism, Socialism, and Democracy*, New York: Harper and Brothers.
- SIEGEL, Donald and Zvi GRILICHES (1991), "Purchased services, outsourcing, computers and productivity in manufacturing", *NBER Working Paper* No. 3678.
- STEIN, Jeremy (1997), "Waves of creative destruction: firm-specific learning-by-doing and the dynamics of innovation", *Review of Economics and Statistics*, 4(2), pp. 265-288.

TRAGER, Mitchell L. and Richard A. Moore (1995), "Development of a longitudinally-linked establishment based register, March 1993 through April 1995", U.S. *Bureau of the Census Working Paper*.

TYBOUT, James R. (1996), "Heterogeneity and productivity growth: assessing the evidence" in ROBERTS and TYBOUT (eds.) (1996), *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity, and Market Structure*, New York: Oxford University Press for the World Bank, pp. 43-72.

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