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Measuring Effective Searchers with Quantity Indexes

Martin McCarthy

ESCoE Discussion Paper 2025-17

November 2025

ISSN 2515-4664

DISCUSSION PAPER

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To measure labour market tightness or estimate aggregate matching functions, it is common to construct measures of 'effective searchers'. These measures aggregate together different types of job seekers, such as the unemployed, employed and those not in the labour force. This paper connects the measurement of effective searchers to index number theory for the first time. This provides several insights. Firstly, the measure commonly used in previous literature is a Lowe quantity index. Secondly, one could instead use quantity indexes that use time-varying job-finding rates, such as a Tornqvist or Fisher index. Finally, one should not measure effective searchers as linear combinations of quantities with time-varying coefficients. The effect of using different quantity indexes is illustrated with Australian data.

Keywords: Index numbers, Aggregation, Labour, Vacancies, Effective Searchers, Job Search

JEL classification: C43, J63, J64

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Published by:
Economic Statistics Centre of Excellence
King's College London
Strand
London
WC2R 2LS
United Kingdom
www.escoe.ac.uk

Measuring Effective Searchers with Quantity Indexes

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Research Discussion Paper
2025-17

November 2025

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Thank you to Jeff Borland, Kevin Fox, Jonathan Hambur, Kevin Lane, Callum Ryan, Avish Sharma, Joyce Tan, and Ani Yadav. Thank you also to the audience at the e61-RBA microdata discussion group. The views expressed in this paper are those of the author and should not be attributed to the Reserve Bank of Australia. Any errors are the sole responsibility of the author.

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https://doi.org/10.47688/https://doi.org/

Abstract

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1. Introduction

There are many types of job seekers, but in some applications it is useful to have a single summary measure of job seekers. One such application is the estimation of matching functions, which are regressions of hires on vacancies and a measure of job seekers (see Petrongolo and Pissarides (2001) for a survey). Another application is measuring labour market tightness by dividing vacancies by a measure of job seekers. Four commonly used summaries of the number of job seekers are:

- **Unemployment:** This measure is simple, but ignores the employed and persons not in the labour force (NILF) even though they can fill vacancies. Moreover, it treats all types of unemployed as equally important.
- **Labour force:** This measure is also simple, but it ignores NILF (even though they can fill vacancies) while weighting employed the same as unemployed (even though the latter fill vacancies at a faster rate).
- **Effective searchers:** This is an aggregate of all types of job seekers, whether unemployed, employed or NILF. It is therefore aligned in scope with vacancies, which can be filled by any type of job seeker. Each type's weight depends on the rate at which they find jobs, so each unemployed person has more weight than an employed or NILF person.
- **Non-employment indexes:** This is an aggregate of types of job seekers other than the employed. It is not aligned in scope with vacancies, since it omits employed persons who may fill vacancies. It can be computed with exactly the same methods as effective searchers aside from the omission of the employed. As such, references to effective searchers in the rest of this paper can be viewed as referring to non-employment indexes as well.

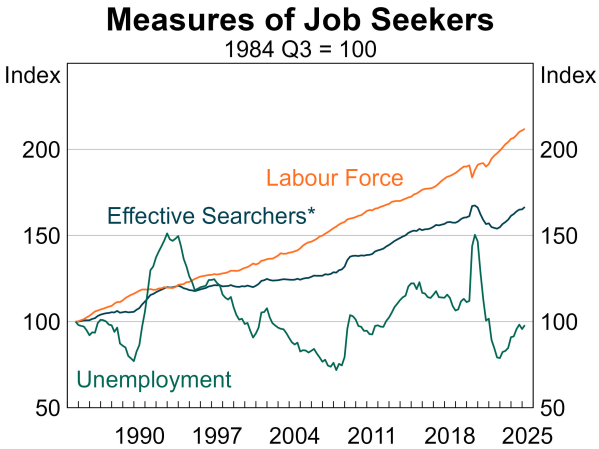
Effective searchers is aligned in scope with vacancies, and is therefore the most conceptually appealing of the four summary measures. The choice of measure is important in practice. Effective searchers has different trends and cyclical behaviour to unemployment and the labour force (Figure 1).[1] Moreover, measures of labour market tightness differ depending on the chosen summary of job seekers. However, while effective searchers is conceptually appealing, it is challenging to know how it should be constructed in practice, as many formulas are possible (Figure 2).

This paper connects the measurement of effective searchers to index number theory for the first time. Ordinarily, index numbers are used to decompose growth in a nominal value into a price index and a quantity index. In this paper, however, index numbers are used to decompose growth in total hires into a job-finding rate index and a quantity index. The job-finding rate index summarises variation in the rates at which job seekers fill vacancies. The quantity index summarises variation in the quantities of job seekers, and can therefore be used to measure effective searchers.

This novel connection to index number theory provides several insights. Firstly, the standard formula for effective searchers in the literature is a Lowe quantity index, although it has not been reviewed as such previously. This standard formula weights the quantity of each type of job seekers using a constant job-finding rate, even if actual job-finding rates have changed greatly over time. Secondly,

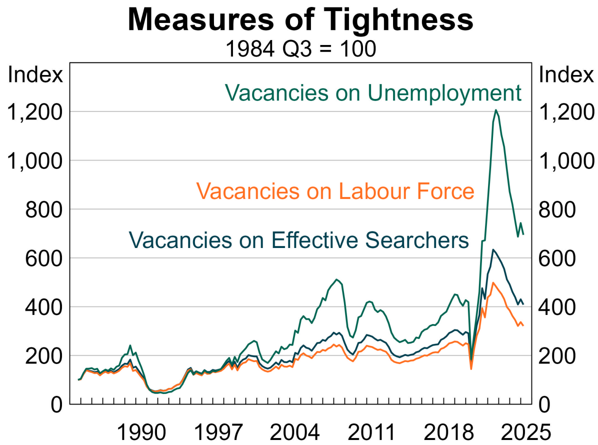
1 In Figures 1 and 2, effective searchers is measured as a chained Tornqvist quantity index (see Section 4).

Figure 1



* Chained Tornqvist index of unemployment, employment and NILF.
Source: RBA.

Figure 2



* Chained Tornqvist index of unemployment, employment and NILF.
Source: RBA.

one could instead measure effective searchers using bilateral quantity indexe that account for time-varying job-finding rates, and the choice of formula can be informed by the axiomatic approach to index number theory. Finally, one should avoid measuring searchers as a linear combination of quantities, as this would not be a 'pure' measures of quantity change. Throughout, the methods are illustrated with Australian data.

Improved measurement of effective searchers will improve estimates of aggregate matching functions. These estimated matching functions are directly useful, as they inform the development and calibration of search and matching models of the labour market. Additionally, the residuals of these estimated matching functions are estimates of the efficiency of the matching process, as they capture variation in hires not explained by effective searchers or vacancies. Improved measurement of effective searchers also implies that vacancies-on-effective searchers will be a better measure of tightness. This may assist central banks and fiscal authorities to stabilise the business cycle, and may be useful in forecasting wages growth and inflation.

This paper begins by framing the measurement of effective searchers as an index number problem (Section 2), and showing that existing methods are Lowe quantity indexes (Section 3). The paper then argues one should measure searchers with a bilateral index (Section 4), and cautions against using weighted sums of quantities with time-varying weights (Section 5). The paper concludes with a discussion of how quantity indexes can be used aggregate across other types of job seekers, or used to aggregate different types of vacancies. The Australian data used throughout is described in Appendix A.

2. Framing Effective Searchers as an Index Number Problem

Index numbers are frequently used in official statistics, including in the System of National Accounts and Consumer Price Indices. Ordinarily, they are used to decompose growth in a nominal value into contributions of price growth and quantity growth. Let:

- $i = 1, ..., N$ denote different types of goods
- $p_t = \left(p_t^1, ..., p_t^N\right)$ be a vector of goods prices in period t
- $q_t = \left(q_t^1, ..., q_t^N\right)$ be a vector of goods quantities in period t

A nominal value, such as nominal consumption, is the dot product of the price and quantity vectors, $\sum_{i=1}^N p_t^i q_t^i$. Index numbers decompose growth in this nominal value into a price index P and a quantity index Q. These are 'bilateral' indexes, because they use the prices and quantities of the two periods being compared.

$$\frac{\sum_{i=1}^N p_t^i q_t^i}{\sum_{i=1}^N p_{t-1}^i q_{t-1}^i} = P\left(p_t, p_{t-1}, q_t, q_{t-1}\right) Q\left(p_t, p_{t-1}, q_t, q_{t-1}\right) \tag{1}$$

The challenge of aggregating together different types of job seekers can be framed as an index number problem, allowing us to draw on the rich literature on index numbers. To do this, I will give the above notation a new interpretation. Let:

- $i = 1, ..., N$ denote different types of searchers
- $p_t = \left(p_t^1, ..., p_t^N\right)$ be a vector of job-finding rates in period t
- $q_t = \left(q_t^1, ..., q_t^N\right)$ be a vector of the quantities of each type of searcher in period t

The job-finding rate of searcher type *i*, is the number of hires of that type h_t^i divided by the number of searchers of that type q_t^i. Job-finding rates differ greatly between types (Figure 3). Total hires, h_t is the dot product of the job-finding rate vector and the quantity vector. Hence, total hires in this new context corresponds to a nominal value in the traditional index number context.

$$h_t = \sum_{i=1}^N h_t^i = \sum_{i=1}^N \left(\frac{h_t^i}{q_t^i}\right) q_t^i = \sum_{i=1}^N p_t^i q_t^i \tag{2}$$

With this new notation, equation (1) states that growth in total hires $\left(\frac{\sum_{i=1}^N p_t^i q_t^i}{\sum_{i=1}^N p_{t-1}^i q_{t-1}^i}\right)$ equals the product of a 'job-finding rate index' P (which summarises growth in job-finding rates) and a quantity index Q (which summarises growth in searcher quantities).

The literature on index numbers studies how one should choose formulas for the indexes. Most formulas are weighted averages of growth in the quantities. The weights are typically shares of nominal values, which in this context, are shares of hires (Figure 4).

Figure 3

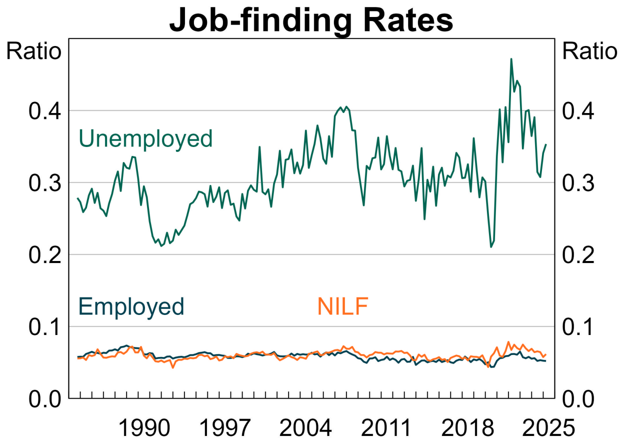
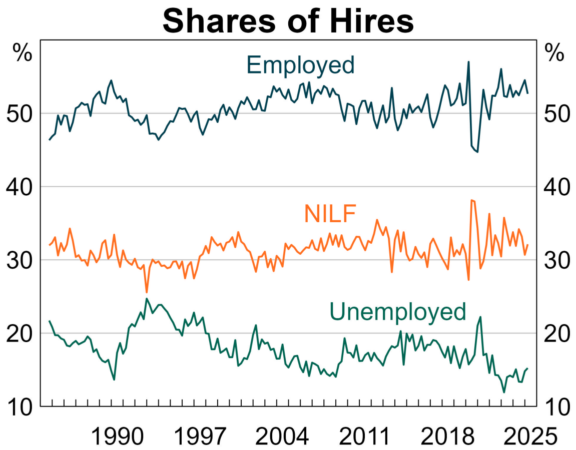


Figure 4



A quantity index is intended to summarise growth in the quantities of searchers, rather than total search effort. A quantity index can, however, capture variation in effort. If a change in a person's search effort results in them changing searcher type, this will be captured by the quantity index. For example, if the types are finely disaggregated, then a person who puts in less effort may switch from 'NILF actively searching' to 'NILF not searching'. This would cause effective searchers to fall, as the former has a higher job-finding rate than the latter. Ordinarily, a quantity index would not capture variation in effort of a given searcher type, such as an increase in the average effort of the unemployed. However, one can account for this by computing the quantity index using 'effort-adjusted' quantities. For example, the quantity of each type in each period could be scaled by time spent on job applications in that period, as in Mukoyama, Patterson and Åžahin (2018).[2]

The connection between effective searchers and index numbers does not appear to have been recognised in the previous literature. Hall and Schulhofer-Wohl (2015) came closest; they measure matching efficiency for each type of searcher, and then use index numbers to aggregate matching efficiency across types. However, they do not consider the measurement of effective searchers itself. Even if good estimates of matching efficiency are available, good measurement of effective searchers is still needed for the estimation of aggregate matching functions or the measurement of labour market tightness.

2.1 Chained versus fixed-base indexes

To measure the level of effective searchers, one can 'chain' the quantity indexes. The level of searchers is set equal to 1 in the earliest period, denoted $t = 0$. The level of effective searchers is then grown from this initial level using indexes that compare the adjacent periods:

$$\underbrace{S_t^{\text{chained}}}_{\text{Effective searchers level}} \equiv \prod_{k=1}^{t} \underbrace{Q(p_{k-1}, p_k, q_{k-1}, q_k)}_{\text{Quantity index for (k-1) to k}}$$

Alternatively, the level of effective searchers can be measured with a 'fixed-base' quantity index instead. Under this approach, the level of searchers in each period t would be set equal to a quantity

2 This approach is not yet feasible in Australia. While the latest Australian time-use survey measures time spent on job search (Australian Bureau of Statistics 2022), the survey has only been run three times in the past three decades, so is not cannot measure variation in search effort at business cycle frequencies.

index that compares quantities in the earliest period 0 and the later period t.

$$\underbrace{S_t^{\text{fixed base}}}_{\text{Effective searchers level}} = \underbrace{Q(p_t, p_0, q_t, q_0)}_{\text{Quantity index for 0 vs t}}$$

For the Lowe quantity index discussed in section 3, using chained quantity indexes or fixed base quantity indexes gives identical results, so this distinction can be ignored. For the Fisher and Tornqvist indexes, the distinction is important, as discussed in section 4.

3. Lowe quantity indexes

The standard measure of effective searchers used in previous work is a linear combination of the quantities of different searchers with constant coefficients. The coefficient for a type is typically some constant 'reference' level of the job-finding rate, p_R^i, such as the average job-finding rate over the sample period (Hornstein, Kudlyak and Lange 2014; Kudlyak 2017; Byrne and Conefrey 2017; Abraham, Haltiwanger and Rendell 2020; Heise, Pearce and Weber 2024).[3]

$$S_t^{\text{standard}} = \sum_{i=1}^{N} p_R^i q_t^i \tag{3}$$

Growth in the standard measure of effective searchers equals a Lowe quantity index, which has not been recognised previously. The Lowe quantity index is the ratio of the value of period t quantities to the value of $(t-1)$ quantities, both valued at the reference job-finding rates, p_R^i.

$$\frac{S_t^{\text{standard}}}{S_{t-1}^{\text{standard}}} = \frac{\sum_{i=1}^{N} p_R^i q_t^i}{\sum_{i=1}^{N} p_R^i q_{t-1}^i} = Q^{\text{Lowe}}\left(p_R, q_t, q_{t-1}\right)$$

To assist in interpretation, it is common to rewrite the Lowe quantity index as a weighted average of growth in the quantities:

$$Q^{\text{Lowe}}\left(p_R, q_t, q_{t-1}\right) = \frac{\sum_{i=1}^{N} p_R^i q_{t-1}^i \left(\frac{q_t^i}{q_{t-1}^i}\right)}{\sum_{i=1}^{N} p_R^i q_{t-1}^i} = w_{t-1}^R \left(\frac{q_t^i}{q_{t-1}^i}\right)$$

The weights w_{t-1}^R are shares of hires if job-finding rates had remained constant at the reference levels, p_R^i.

$$w_{t-1}^R = \frac{p_R^i q_{t-1}^R}{\sum_{i=1}^{N} p_R^i q_{t-1}^i} \tag{4}$$

A key advantage of the Lowe index is that it can be computed even if data on job-finding rates are infrequent or only available with long lags.[4] This advantage is also shared by Young index, which uses the same data.

The Lowe index is preferable to the Young index from an 'axiomatic' or 'test' approach. Neither can be evaluated using the usual tests for bilateral indexes, as they do not use job-finding rates from the two periods being compared and hence are not bilateral indexes. However, when they are evaluated according to an alternative set of tests, Lowe satisfies all 12 while Young only satisfies 10 (International Labor Organization 2004).

3 Blanchard and Diamond (1989) and Mackey (2024) also use linear combinations of quantities with constant coefficients. Blanchard and Diamond (1989) left the coefficients unspecified until they estimated the matching regression, when the coefficients on different types were estimated alongside other unknown parameters. Mackey (2024) the quantity of job-seekers are defined narrowly to only include those likely to search (e.g. NILF job-seekers rather than all NILF), and then each is given a coefficient of 1.

4 A similar situation arises for Consumer Price Indexes in many countries. If price data is timely and frequent but data on expenditure shares is infrequent and lagged, statistical agencies cannot compute bilateral indexes. Instead, they tend to use Lowe indexes, reweighting every year or few years.

Another advantage of the Lowe index is that it is invariant to choosing a 'base' searcher type. That is, if the job-finding rates p_i^R in its definition are replaced with job-finding rates relative to a base type, $\left(\frac{p_R^i}{p_R^b}\right)$, growth in effective searchers is unchanged.[5] This is useful, as the choice of whether to use a base type is arbitrary. This property should not be taken for granted, as it is not satisfied by the measures discussed in section 5.

The key disadvantage of the Lowe quantity index is that it does not use up-to-date job-finding rates. The standard method of measuring effective searchers in the literature uses job-finding rates, reflecting a consensus that the index should put more weight on quantity growth of searcher types with high job-finding rates (e.g. the unemployed) than low job-finding rates (e.g. NILF). If one accepts this view, it would also be natural for the weights on different types to reflect the job-finding rates prevailing at the time. Unfortunately, with a Lowe quantity index whose weights are never updated, growth in effective searchers in one period (say Q2 2025) may be based on job-finding rates at a very different time (such as the average rates from 1985 to 2025).

Whether this makes a difference in practice depends on how much job-finding rates vary over the sample period, which will differ depending on the country under study and the level of aggregation. In Australia the issue is important: quantity indexes that use constant job-finding rates (e.g. Lowe) differ noticeably from those that use time-varying job-finding rates (e.g. Tornqvist, Fisher) (Figure 5). The importance of this issue is increasing over time; as time series of effective searchers lengthen, the growth rates in some periods will be influenced by job-finding rates at increasingly distant times.

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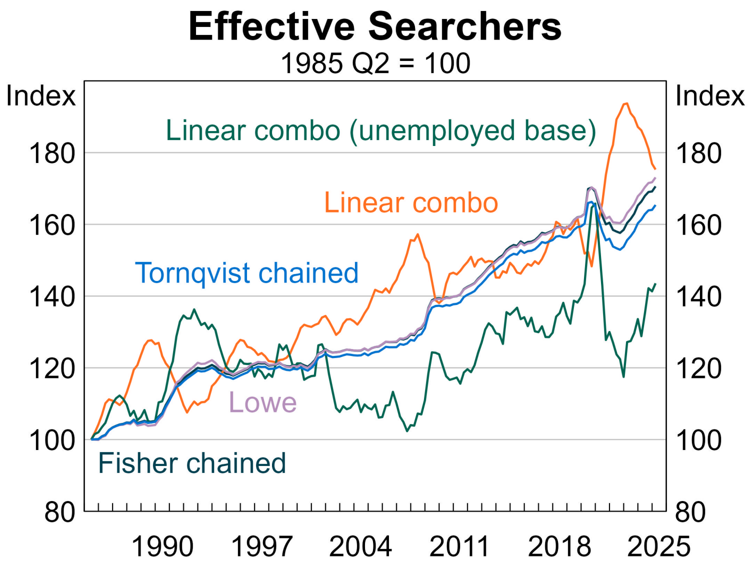
5 The standard measure would become: $S_t = \sum_{i=1}^{N} \frac{p_R^i}{p_R^b} q_t^i = \left(\frac{1}{p_R^b}\right) \sum_{i=1}^{N} p_R^i q_t^i$. This scales the level of effective searchers in all periods by a constant, $\left(\frac{1}{p_R^b}\right)$, which has no effect on growth rates. Changing the level without the growth rates is typically unimportant. For example, if we estimated the following matching regression, scaling effective searchers by a constant would change the intercept β_0, but not affect the slope parameters β_1, β_2 or matching efficiency ε_t.

$$log(h_t) = \beta_0 + \beta_1 log(S_t) + \beta_2 log(V_t) + \varepsilon_t$$

Figure 5


Effective Searchers
1985 Q2 = 100
Index
Index
Linear combo (unemployed base)
Linear combo
Tornqvist chained
Lowe
Fisher chained
180
160
140
120
100
80
1990
1997
2004
2011
2018
2025

4. Bilateral quantity indexes

If data on quantities and job-finding rates are available for all periods, one can compute bilateral indexes. This bilateral indexes considered in this paper are well known, but it is useful to define them briefly for those unfamiliar with index number theory. The Laspeyres index and Paasche index are weighted means of growth in the quantity of each searcher type.

$$Q^{\text{Laspeyres}} = \sum_{i=1}^{N} w_{t-1}^{i} \left(\frac{q_t^i}{q_{t-1}^i} \right)$$

$$Q^{\text{Paasche}} = \left(\sum_{i=1}^{N} w_{t-1}^{i} \left(\frac{q_t^i}{q_{t-1}^i} \right)^{-1} \right)^{-1}$$

The weights w_t^i are shares of hires, which reflect up-to-date job-finding rates (equation 5). This differs from the Lowe index, whose weights reflect what the hires share would have been at some reference level of job-finding rates (equation 4).

$$w_t^i = \frac{h_t^i}{h_t} = \frac{p_t^i q_t^i}{\sum_{i=1}^{N} p_t^i q_t^i} \tag{5}$$

The Fisher index is a geometric average of the Laspeyres and Paasche indexes. The Tornqvist index is a weighted mean of quantity growth, but uses hires shares from both periods. Both of these indexes treat the two periods being compared symmetrically, which is intuitively appealing.

$$Q^{\text{Fisher}} = \sqrt{Q^{\text{Laspeyres}} Q^{\text{Paasche}}}$$

$$log\left(Q^{\text{Tornqvist}}\right) = \sum_{i=1}^{N} \left(\frac{w_{t-1}^i + w_t^i}{2} \right) log\left(\frac{q_t^i}{q_{t-1}^i} \right)$$

The key advantage of all of these bilateral indexes is that they use job-finding rates from one or both of the periods being compared, rather than a reference job-finding rate that may relate to a distant time. For example, when measuring effective searchers growth from Q1 2025 to Q2 2025, a bilateral index would use job-finding rates from one or both of those quarters, while a Lowe index would use a reference job-finding rate that may relate to a quite distant time, such as the average rate from 1985 to 2025.

All of these bilateral indexes are invariant to the choice of 'base' searcher type. In the formula for the weights (equation 5), if job-finding rates p_t^i were replaced with job-finding rates relative to a base type $\left(\frac{p_t^i}{p_t^b}\right)$, the weights would be unchanged. Hence measured growth rate of effective searchers would also be unchanged.

The previous literature has not explicitly rejected the Tornqvist or Fisher index when adopting the Lowe index. Rather, previous authors may not have not realised they could use these alternative formulas, as the connection to index number theory had not been made at the time.

4.1 Choosing among bilateral indexes

One can assess bilateral index formulas using the axiomatic or test approach, as was done for the Lowe and Young indexes in Section 3. Diewert (2021) shows that Fisher indexes satisfy a set of 20 desirable tests. Laspeyres, Paasche and Tornqvist indexes do not satisfy all the tests, but the Tornqvist index tends to closely approximate Fisher indexes in most practical situations, and hence can be viewed as approximately satisfying all the tests. This suggests that practitioners should adopt the Tornqvist or Fisher index. These indexes are often used in practice. For example, the ABS uses Tornqvist quantity indexes to measure capital services (Australian Bureau of Statistics 2007) while the US Personal Consumption Expenditures Price Index is a Fisher index (Bureau of Labor Statistics 2011).

The 'economic' approach is another common way to assess bilateral indexes, but it is not straightforward to apply it to measuring effective searchers (see Appendix B).

4.2 Fixed-base vs chained indexes

One can measure the level of effective searchers with a fixed-base or chained index, as explained in Section 2.1. If a fixed-base index is used, then the level of effective searchers in a period t depends only on the quantities and job-finding rates in the earliest period 0 and the current period t. If a chained index is used, then the level of effective searchers may also depend on the quantities and job-finding rates of the intermediate periods $1, 2, ..., t-1$. Consequently, the fixed-base and chained indexes can differ. One concern is that, if the quantities were the same in 0 and t, the chained index may show non-zero growth. This phenomenon is called 'chain drift'. It is difficult to give intuition for the sign and magnitude of chain drift (though see section 7 of Diewert 2021b). Empirical work in other contexts tends to find that quantity indexes show more chain drift when the prices (in the case, job-finding rates) are volatile and frequently updated.

To the quantify the importance of this issue for Australia, chained and fixed-base Tornqvist and Fisher indexes were computed using the same quarterly data on three types of job seeker as the rest of this paper (Figure 6). The chained and fixed-base versions of the indexes differ only slightly. Chained and fixed-base indexes were also computed using monthly data on eleven types of job seeker (Figure 7). The two Tornqvist indexes were similar, but the two Fisher indexes diverged dramatically. These results suggest that the difference between fixed-base and chained indexes will depend on the particular dataset under consideration.

Practitioners should compute both chained and fixed-base Tornqvist and Fisher indexes for their dataset. If they find the chained and fixed-base indexes are similar, then they can use either with little impact. If the measures diverge for their dataset, it would be best to compromise between these two extremes. This can be done by reweighting annually, as is often by National Statistical Offices.

Figure 6

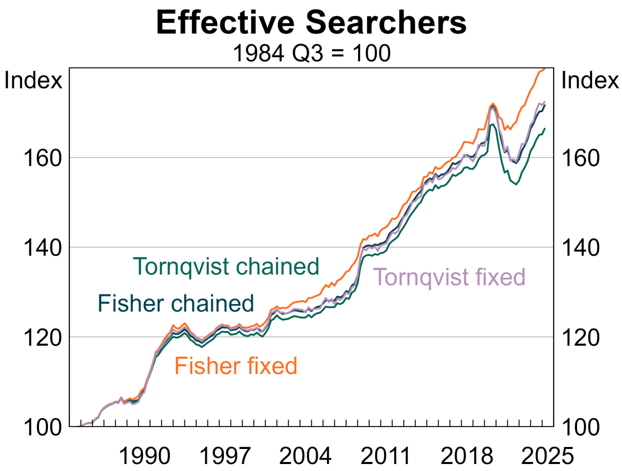
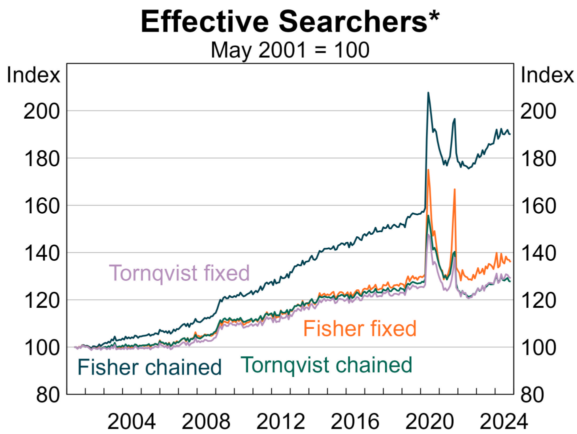


Figure 7



* Using data on 11 types of searcher.

Source: RBA.

5. Linear combinations of quantities

The standard measure of effective searchers is a linear combination of the levels of quantities with constant coefficients based on job-finding rates in a reference period (equation 3). If the time series is long, growth in effective searchers in some periods will depend on job-finding rates in a reference period that is distant in time. As explained in section 4, one solution is to use bilateral indexes, as they use time-varying weights. An alternative solution is to use a linear combination of quantities, but with time-varying coefficients (equation 6). The level of effective searchers is a linear combination of quantities, where the coefficients are an m-period trailing moving average of job-finding rates. Unfortunately, this measure is not appropriate, as this section explains.

$$S_t^{\text{Linear combo}} = \sum_{i=1}^{N} \left(\frac{1}{k} \sum_{k=1}^{m} p_{t-k}^{i} \right) q_i^t \tag{6}$$

The key issue with this 'linear combination' method is that it is not a pure measure of changes in the quantities of job seekers. If all quantities were constant, but job-finding rates changed, then effective searchers would change. This is most obvious when the coefficients are unsmoothed job-finding rates, so $m = 1$. In this case, this measure of effective searchers equals total hires h_t (see equation (2)). Any variation in job-finding rates is immediately reflected in measured effective searchers, regardless of its source. However, even if the coefficients are smoothed job-finding rates, $m \geq 2$, variation in job-finding rates is reflected in measured effective searchers, albeit with a delay due to smoothing.

As discussed in section 2, a quantity index will only capture variation in search effort that reflects searchers changing types. While one could apply a quantity index to 'effort-adjusted' quantities, this is not always feasible given the available data. Hence, one may hope that the linear combination measure could better capture variation in effort, since it reflects variation in job-finding rates. While variation in job-finding rates does reflect variation in search effort, it also reflects variation in labour demand. An exogenous increase in labour demand would raise job-finding rates, which would raise this measure of effective searchers even if the quantities of searchers and their search effort was unchanged. Hence, the measure of searchers in equation (6) is not a clean 'supply-side' measure, but instead an amalgam of supply and demand influences. To ensure effective searchers has the desired interpretation, it is essential to use a quantity index.

In the above approach, one could use coefficients that are trailing moving averages of the job-finding rate relative to a 'base' searcher type. For example, one could use job-finding rates of each searcher type relative to the job-finding rate of the unemployed.

$$S_t^{\text{Linear combo with base}} = \sum_{i=1}^{N} \left(\frac{1}{m} \sum_{k=1}^{m} \frac{p_{t-k}^{i}}{p_{t-k}^{b}} \right) q_i^t \tag{7}$$

This measure is also not a 'pure' measure of quantity change. If the quantities of each searcher type are constant, but the relative job-finding rates change, measured effective searchers would change. This is a concern, as the relative job-finding rates are still influenced by labour demand. For example, in many advanced economies, labour demand during the COVID pandemic fell greatly for some industries with below-average skill levels (e.g. food and accommodation) relative to those with higher skill levels (e.g. professional, scientific and technical services). This will tend to reduce labour demand and hence job-finding rates for searcher types with below average skills (the NILF, unemployed) relative to those with higher average skills (the employed). This change in relative job-finding rates is due to labour demand, but would still be a mechanical source of variation in this measure of effective searchers. To ensure effective searchers has the intended interpretation as a 'supply-side' measure, one should compute it with a quantity index.

Another disadvantage of these linear combination methods is that they are extremely sensitive to whether a 'base' type is used, and which base type is chosen. The linear combination without a base type (equation (6)) and the linear combination with a base type (equation (7)) can differ greatly in practice. When applied to Australian data, the two series tend to move in opposite directions (Figure 5). This sensitivity to base type is concerning, as the choice of base type is largely arbitrary.

6. Conclusion

This paper studied aggregation of job seekers with different labour market status, which can be done with a coarse classification (unemployed, employed or NILF) or a fine classification (such as short-term unemployed, long-term unemployed, and so on). Its key contribution is to reframe the problem of measuring effective searchers as an index number problem (Section 2). This reframing provided insight into how one should measure effective searchers, whether one's goal is to estimate matching functions or measure tightness. If data on job-finding rates is infrequent or only available with a lag, one should use a Lowe quantity index (Section 3). However, if data on job-finding rates is frequent and timely, one can and should use a bilateral quantity index, such as a Tornqvist or Fisher index (Section 4). One should never use a linear combination of quantities with time-varying coefficients, as this is not a pure measure of quantity change and is sensitive to the choice of base seaarcher type (Section 5).

While this paper focusses on aggregation of job seekers of different labour market statuses (such as unemployed and NILF), its insights apply more broadly. Firstly, one could construct measures of effective searchers by aggregating other types of job seekers, provided they compete for the same pool of vacancies. This problem can be framed as an index number problem in exactly the same way as Section 2, and a quantity index should be used. One could even construct measures of effective vacancies by aggregating different types of vacancies, provided those vacancies compete for the same pool of workers. This can be framed as an index number problem as explained in Appendix C. This paper is not, however, intended to provide insight into aggregation across a set of distinct regional labour markets, each of which has its own pool of job seekers and pool of vacancies. While one could use a quantity index to aggregate job seekers across markets, and then separately use a quantity index to aggregate vacancies across markets, this is not ideal. Aggregating searchers separately from vacancies in this way discards information about whether the markets with many searchers are also those with many vacancies. This issue is studied in a separate literature on 'mismatch', which is surveyed in (Petrongolo and Pissarides 2001)).

Careful measurement of effective searchers provides a solid foundation for future empirical work. Firstly, improved measures of effective searchers can be used to estimate aggregate matching functions. These estimated matching functions can inform the calibration of search and matching models, and imply estimates of matching efficiency that provide evidence on changes in the matching process. Secondly, effective searchers measures can be used to measure labour market tightness, which may help explain and forecast wages growth and inflation.

Appendix A: Data

All graphs except for Figure 7 show quarterly frequency data from 1984 Q3 To 2025 Q1. In these graphs, job seekers are classified into three types: employed; unemployed and NILF. For each searcher type, I obtain seasonally-adjusted monthly quantities from the labour force survey, which is a monthly survey of Australia's resident population aged 15+ years.[6] For each type, I also use a seasonally-adjusted quarterly hires series constructed by the Reserve Bank of Australia using longitudinal labour force survey microdata. This microdata is available within the Australian Bureau of Statistics' Datalab environment.[7] Details of the construction of the hires series are described in Sharma (2024). Using quarterly data on hires h_t^i and quantities q_t^i, I compute job-finding rates $\left(\frac{h_t^i}{q_t^i}\right)$, shares of hires $\left(\frac{h_t^i}{h_t}\right)$, and quantity indexes.

Figure 7 shows quantity indexes constructed using monthly frequency data from May 2021 to October 2024. The quantity indexes use seasonally-adjusted monthly quantities and hires for eleven job seeker types. The quantity and hires series were constructed by Tan (2025) using longitudinal labour force survey microdata. The eleven types are:

- Two types of employed: fully employed and underemployed
- Four types of unemployed: short-term; medium-term; long-term; and waiting to start a job
- Five types of NILF: actively looking; passively looking; not looking; unable to work or retired; and waiting to start a job

6 Available at: https://www.abs.gov.au/statistics/labour/employment-and-unemployment/labour-force-australia/latest-release

7 https://www.abs.gov.au/statistics/microdata-tablebuilder/available-microdata-tablebuilder/longitudinal-labour-force-australia

Appendix B: Applying the Economic Approach

Section 4 argued for the use of the Tornqvist or Fisher index based on the axiomatic or test approach. In other contexts it is common to assess bilateral indexes using the economic approach. This appendix explains why this approach would be challenging.

In the words of Neary (2004), the economic approach 'assumes that quantities arise from optimizing behavior and explores how closely empirical indices approximate to some "true" (and usually unobservable) index based on economic theory'. For example, one could assume that a representative household chooses the quantities of goods and services to maximise their utility subject to a budget constraint, and show that a particular price index equals a 'true' price index under an assumption about the utility function (Diewert 1976).

The natural theoretical setting for a measure of effective searchers is a search and matching model. Specifically, one can assume that a matching function relates total hires to effective searchers and vacancies, as in Abraham *et al* (2020). To apply the economic approach in this context, one would need to specify microfoundations for the matching function. A large literature provides microfoundations for matching functions (see Petrongolo and Pissarides (2001) and Stevens (2007)). However, as far as I know, there are no microfoundations in the previous literature that have all three of the following features, which seem important for the use of the economic approach:

- **They must feature heterogeneity by job seeker type.** Urn-ball models tend to assume that job seekers are all identical. Mismatch models assume there are multiple markets, each with job seekers and vacancies, and that matching is instant within a market. The markets may correspond to different locations, industries or skills. However, this is different from the problem of measuring effective searchers, where job seekers of multiple types often compete for the same vacancies.
- **They must suggest a matching function with nice theoretical properties and good empirical fit.** This is not the case in simple urn-ball models, but is true for some other models.
- **They must feature optimising behaviour by the job seeker, the firm, or both.** Otherwise, one cannot assess a bilateral index under a particular assumption about job seeker utility functions or firm production functions. This is rarely the case.

Future work could aim to develop new microfoundations for the matching process with all three of these features. One could then define some theoretical index of effective searchers in this microfounded model, and assess if quantity indexes approximate the theoretical index. However, in my view the axiomatic approach is likely to be the dominant way of choosing among bilateral indexes for effective searchers. This is because the axiomatic approach relies on uncontroversial assumptions. In contrast, the economic approach as applied to effective searchers will require making many contentious modelling choices, given the wide variety of approaches used to microfound the matching process (urn-ball, mismatch and so on). This is not true of the economic approach in other contexts. When measuring the consumer price index, for instance, it is uncontroversial that one should view the household as solving a utility maximisation problem.

Appendix C: Measuring Effective Vacancies

This note described methods for measuring 'effective searchers', which is an aggregate of the quantity of different types of job seeker. However, these methods are equally applicable to measuring 'effective vacancy', which is an aggregate of the quantity of different type of vacancy. For example, one could compute effective vacancies by aggregating 'vacancies with an external recruiter' and 'vacancies without an external recruiter'. Applying the methods of this note to vacancies is simply a matter of re-interpreting the existing notation. Let:

- $i = 1, , N$ denote different types of vacancies
- $p_t = \left(p_t^1, , p_t^N\right)$ be a vector of job-filling rates in period t. The job-filling rate of type j, defined as $\frac{h_t^i}{q_t^i}$, is the number of hires per open vacancy.
- $q_t = \left(q_t^1, , q_t^N\right)$ be a vector of the quantities of each type of vacancy in period t.

With this notation, we can write total hires in terms of vacancies and job-filling rates (not job-finding rates!) (see equation (2)). This implies that we can decompose total hires growth into a job-filling rate index P and a quantity index of vacancies Q (equation (1)). Hence, one can measure effective vacancies using quantity indexes (such as Lowe, Fisher or Tornqvist) or with linear combinations of quantities. Hence, one can argue for the use of a bilateral index such as Tornqvist or Fisher so that up-to-date job-filling rates are used, as in Section 4.

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