Measuring Effective Searchers with Quantity Indexes

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Views expressed are my own and not necessarily those of the RBA.

Motivation

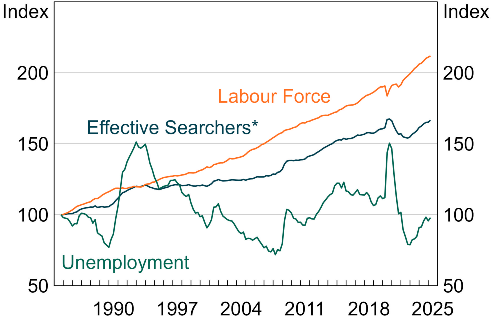
- There are many types of job-seekers. In this paper, the types are: unemployed; employed; and not in the labour force (NILF). Finer classifications are possible.
- in some applications it is useful to have a single summary measure of job seekers:
  - Estimation of matching functions, which are regressions of hires on vacancies and a measure of job seekers (Petrongolo and Pissarides 2001)
  - Measuring labour market tightness by dividing vacancies by a measure of job seekers.

Motivation

- Common summaries job-seekers include:
  - **Unemployment:** 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:** TSimple, 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:** An aggregate of all types of job seekers. 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.
  - **Non-employment indexes:** An aggregate of types of job seekers other than the employed. Not aligned in scope with vacancies, as it omits employed persons who may fill vacancies. Can be computed with same methods as effective searchers.

Measures of Job Seekers

1984 Q3 = 100

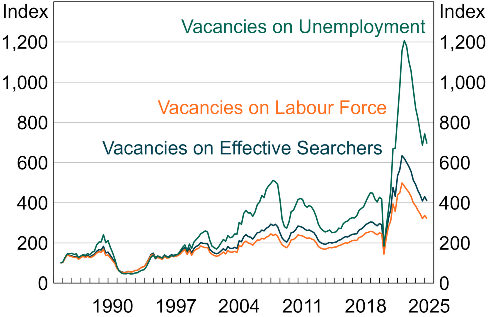


* Chained Tornqvist index of unemployment, employment and NILF.

Source: RBA.

Measures of Tightness

1984 Q3 = 100



* Chained Tornqvist index of unemployment, employment and NILF.

Source: RBA.

This paper's contribution

- I study how one should choose a formula for effective searchers
- To do this, I connect this problem to index number theory for the first time. This provides several insights:
  1. The standard method in the literature is a Lowe quantity index
  2. One can use bilateral quantity indexes to account for time-varying job-finding rates
  3. One should avoid using linear combinations of quantities with time-varying weights.

An Index Numbers in General

Denote

- $i = 1, ..., N$ 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, $\sum_{i=1}^N p_t^i q_t^i$. It can be decomposed into a price index P and a quantity index Q.

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

Index Numbers for Effective Searchers

We re-interpret our notation:

- $i = 1, ..., N$ 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.

Index Numbers for Effective Searchers

Total hires, h_t is the dot product of the job-finding rate vector and the quantity vector. Hence, total hires is analogous to a nominal value.

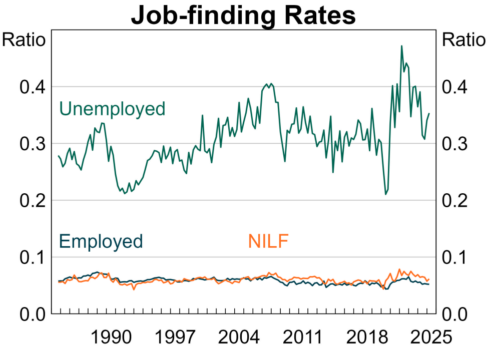
$$h_t = \sum_{i=1}^{N} h_t^i = \sum_{i=1}^{N} \left(\frac{h_t^i}{q_t^i} \right) q_t^i = \sum_{i=1}^{N} p_t^i q_t^i$$

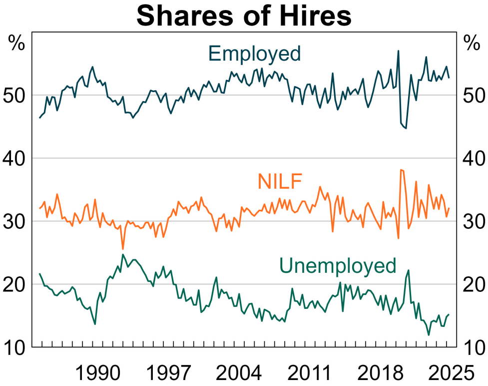
This implies that total hires growth can be decomposed into a job-finding index P and a job-seeker quantity index Q.

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

Index Numbers for Effective Searchers

Job-finding rates are like prices
Shares of hires are like expenditure shares





Chained versus fixed-base indexes

To measure the *level* of effective searchers, one can 'chain' the quantity indexes. Set the level of searchers to 1 in period 0. Then grow effective searchers using quantity indexes that compare the adjacent periods:

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

Alternatively, one can use a 'fixed-base' quantity index. Compute the level of searchers in each later period using a quantity index that compares period 0 quantities to period t quantities

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

For the Lowe quantity index discussed shortly, these are equivalent. But for other indexes, these can differ greatly.

Insight 1 - Standard Measure is a Lowe Index

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:

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

Examples: Hornstein, Kudlyak, and Lange (2014), Kudlyak (2017), Byrne and Conefrey (2017), Abraham, Haltiwanger, and Rendell (2020), and Heise, Pearce, and Weber (2024).

Insight 1 - Standard Measure is a Lowe Index

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.

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

Insight 1 - Standard Measure is a Lowe Index

- A benefit 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.
- This advantage is also shared by Young index, which uses the same data. However, Lowe has better axiomatic properties than Young (International Labor Organization 2004).
- The problem is that 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). This is an issue as job-finding rates vary over time.

Insight 2 - Use bilateral indexes

If data on quantities and job-finding rates are available for all periods, one can compute bilateral indexes. E.g.

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

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

The weights w_t^i are shares of hires, which reflect up-to-date job-finding rates.

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

Insight 2 - Use bilateral indexes

- If data on quantities and job-finding rates are available for all periods, one can compute bilateral indexes.
- Bilateral indexes 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.
- E.g. To measure effective searchers growth from Q1 2025 to Q2 2025, a bilateral index would use job-finding rates from one or both of those quarters. A Lowe index may use job-finding rates from a distant time, like the 1985 to 2025 average.

Insight 2 - Use bilateral indexes

Many familiar bilateral indexes could be used. E.g.

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

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

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

Insight 2 - Use bilateral indexes

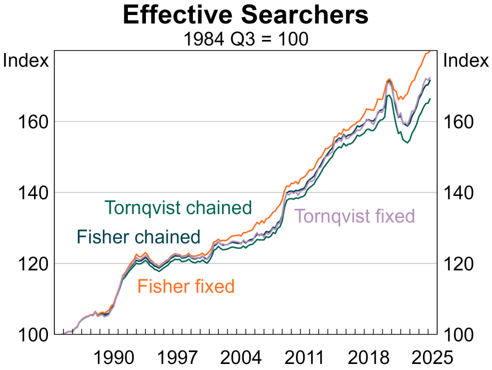
The Fisher index is a geometric average of the Laspeyres and Paasche indexes. The Tornqvist index is a weighted mean of quantity growth, but uses hires shares from both periods.

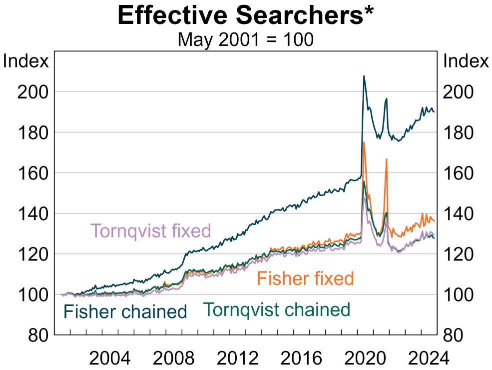
$$Q^{\text{Fisher}} = \sqrt{Q^{\text{Laspeyres}} Q^{\text{Paasche}}}$$

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

One can assess bilateral index formulas using the axiomatic or test approach. 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 is typically close to Fisher, so approximately satisfies the tests. This suggests using Tornqvist or Fisher.

Insight 2 - Use bilateral indexes - Fixed-base or chained?





* * Using data on 11 types of searcher.
Source: RBA.

Insight 3 - Avoid 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

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

A natural way to account for time-varying job-finding rates is to use time-varying coefficients. E.g. An m-period trailing moving average of job-finding rates.

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

Insight 3 - Avoid linear combinations of quantities

- 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, as shown earlier:

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

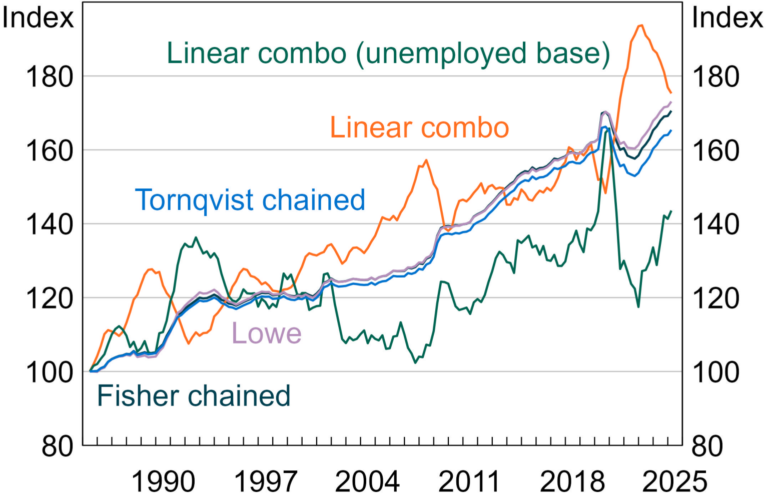
- Any variation in job-finding rates is immediately reflected in measured effective searchers, regardless of its source. However, even if the coefficients are smoothed job-finding rates, $m \geq 2$, variation in job-finding rates is reflected in measured effective searchers, albeit with a delay due to smoothing.

Insight 3 - Avoid linear combinations of quantities

- Linear combinations of quantities can be computed with a 'base searcher type'. I.e. You express the job-finding rate of each type relative to a base type, like the unemployed. They are sensitive to this arbitrary choice, unlike the quantity indexes.
- Some argue for linear combinations in an effort to account for variable search effort. However, this is misguided. Search effort

Effective Searchers

1985 Q2 = 100



Conclusion

- Effective searchers are a conceptually appealing summary of job-seekers, as they are aligned in scope with vacancies and give each searcher type a different weight.
- The choice of formula for effective searchers makes a big difference.
- I connect the choice of formula to index number theory, providing 3 insights.
    1. The standard method in the literature is a Lowe quantity index
    2. One can use bilateral quantity indexes to account for time-varying job-finding rates
    3. One should avoid using linear combinations of quantities with time-varying weights.

References I

Abraham, Katharine G., John C. Haltiwanger, and Lea E. Rendell (None 2020). "How Tight Is the US Labor Market?" In: *Brookings Papers on Economic Activity* 51.1 (Spring, pp. 97–165. DOI: None. URL: https://ideas.repec.org/a/bin/bpeajo/v51y2020i2020-01p97-165.html.

Byrne, Stephen and Thomas Conefrey (Aug. 2017). *A Non-Employment Index for Ireland*. Economic Letters 09/EL/17. Central Bank of Ireland. DOI: None. URL: https://ideas.repec.org/p/cbi/ecolet/09-el-17.html.

Diewert, Erwin (Apr. 2021). *The Axiomatic or Test Approach to Index Number Theory*. URL: https://economics.ubc.ca/wp-content/uploads/sites/38/2021/04/pdf_paper_diewert-erwin_IMFCPIChapter3.pdf.

References II

- Heise, Sebastian, Jeremy Pearce, and Jacob P. Weber (Oct. 2024). *Wage Growth and Labor Market Tightness*. Staff Reports 1128. Federal Reserve Bank of New York. DOI: 10.59576/sr.1128. URL: https://ideas.repec.org/p/fip/fednsr/98935.html.
- Hornstein, Andreas, Marianna Kudlyak, and Fabian Lange (None 2014). "Measuring Resource Utilization in the Labor Market". In: *Economic Quarterly* None.1Q, pp. 1–21. DOI: None. URL: https://ideas.repec.org/a/fip/fedreq/00013.html.
- International Labor Organization (2004). "Consumer price index manual: Theory and practice". In: ed. by International Labor Office. Geneva. Chap. 16. URL: https://webapps.ilo.org/CPI/doc/cpi_manual_en.pdf.
- Kudlyak, Marianna (None 2017). "Measuring Labor Utilization: The Non-Employment Index". In: *FRBSF Economic Letter* None.None, None. DOI: None. URL: https://ideas.repec.org/a/fip/fedfel/00123.html.

References III

- Mukoyama, Toshihiko, Christina Patterson, and AyÅŸegÃ¼l Åžahin (Jan. 2018). "Job Search Behavior over the Business Cycle". In: *American Economic Journal: Macroeconomics* 10.1, pp. 190–215. DOI: None. URL: https://ideas.repec.org/a/aea/aejmac/v10y2018i1p190-215.html.
- Petrongolo, Barbara and Christopher A. Pissarides (June 2001). "Looking into the Black Box: A Survey of the Matching Function". In: *Journal of Economic Literature* 39.2, pp. 390–431. DOI: 10.1257/jel.39.2.390. URL: https://www.aeaweb.org/articles?id=10.1257/jel.39.2.390.

Appendix

Variation in search effort

- A quantity index is a 'pure' measure of quantity change. It'll cover variation in search effort only if an individual is changing types. Not variation in the effort of a given type.
- E.g. 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.

Variation in search effort

- The linear combination of quantities cannot isolate variation in job-finding rates just due to search effort. It'll also capture variation in job-finding rates, e.g. demand shocks. It lacks a nice 'supply-side' interpretation.
- Instead, use a quantity index, but with '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).