International Economics and Economic Policy (2026) 23:42
https://doi.org/10.1007/s10368-026-00714-x

RESEARCH

A method for the gender disaggregation of Okun's law

Martin Boďa[1,2] · **Michaela Tichá**[2]

Received: 29 September 2025 / Accepted: 20 January 2026 / Published online: 28 March 2026

Abstract
For the case of a slowly time-varying Okun's law, the paper proposes a method to identify male and female Okun coefficients based upon the trajectory of the economy-wide Okun coefficient. The method rests upon a disaggregation principle that requires that gender-specific Okun coefficients be in "accounting" agreement with economy-wide Okun coefficients, which is not recognized in conventional applications. Albeit equally applicable also for the difference version of Okun's law, the method is demonstrated with the more general gap version for the Group of Seven (G7) economies over a period 1991–2022. The demonstration reveals that the conventional approach often leads to implausible trajectories of Okun coefficients and that the unemployment-output nexus for the past three decades did not have constant features. Furthermore, male unemployment need not be universally more exposed to the business cycle, but gender sensitivity may alternate over time with a little difference between males and females.

Highlights
- A method to identify gender-specific Okun coefficients for an economy is proposed.
- The method requires time-varying economy-wide Okun coefficients.
- The method is usable with both the gap and difference version of Okun's law.
- A demonstration for the G7 economies shows that Okun coefficients vary in time.
- Gender-sensitivity to the business cycle may alternate and may not be universal.

Keywords Okun's law · Gender-specific Okun coefficients · Time-varying coefficients · Disaggregation

JEL Classification E23 · E32

Extended author information available on the last page of the article

1 Introduction

As a relatively stable empirical relationship that associates unemployment and output over the business cycle, Okun's law is a popular instrument of short-run macroeconomic policy-making and forecasting. In the recent decade, there have been several attempts to adapt the economy-wide Okun equation in order to study how male and female (cyclical) unemployment responds to (cyclical) variation in output (e.g. Belaire-Franch and Peiró 2015). These explorations frequently took into account gender and age simultaneously, by estimating Okun's law separately for different age cohorts (e.g. Hutengs and Stadtmann 2014; Dunsch 2017; Evans 2018; Kim and Park 2019; An et al. 2022). The research interest in gender-specific effects in Okun's law is driven by empirical evidence from European countries that comes as two stylized facts. It is believed that young labour force suffers most owing to business cycles regardless of gender (e.g. Dunsch 2017), and that male labour force may be more exposed to business cycle fluctuations than female labour force (e.g. Hutengs and Stadtmann 2014; Dunsch 2017).

Against a backdrop of these hypotheses, Okun's law offers a natural means of investigating whether genders (possibly stratified by age cohorts) are equally exposed to business cycles. Yet, these analyses are rendered in a somewhat simplistic manner as they only restate a generic Okun equation by replacing total unemployment by its gender-specific counterparts, and eventually repeat the estimation method that is normally applied to the generic equation. Nonetheless, Boďa and Považanová (2020) and Boďa et al. (2024) have lately cautioned against this practice in the context of regional applications by invoking the disaggregation principle. If Okun's law is believed to hold for a national economy, individual regional estimates must conform to the economy-wide estimate and aggregate to it. Naturally, the caveat also applies to cases when the economy is sliced into the male and female components of the labour force to measure their cosensitivity with cyclical fluctuations. Nonetheless, the approach advanced by Boďa and Považanová (2020) and Boďa et al. (2024) is not applicable here as it would require weights by which both genders contribute to aggregate output, which are unobservable and unknown. Traditional approaches may be simple, but produce estimates that are structurally inconsistent as is explained in Section 2. Furthermore, they tend to adopt formulations that treat Okun's law as static, which runs counter to the widespread belief that the intensity of the unemployment-output nexus varies in time (e.g. Huang and Lin 2008, Furceri et al. 2020). The supposable time-varying feature of Okun's law is reflected in this paper, and it is recognized that the Okun coefficient varies or may vary in time.

This paper responds to the flaw of the prior approaches and proposes a method to disaggregate a time-varying economy-wide Okun coefficient to gender-specific Okun coefficients in a manner that assures consistency between the former and the latter. Conceptually, male and female Okun equations are first considered as a bivariate simultaneous system, and the conditions under which they aggregate to an economy-wide equation are studied, which is then utilized to extract male and female Okun coefficients from the economy-wide Okun coefficient. The method is implemented for a time-varying setting with Okun coefficients modelled as a random walk by the VC (hence, varying-coefficient) method of Schlicht (1985, 2021) for two main reasons. First, the VC method has lately become fairly popular in research on Okun's law (Jalles 2019; Furceri et al. 2020). Second, the method in fact posits a structural model that is yet not implemented in a state space framework with the use of the Kalman filter, but an extension of least squares is utilized that allows an easier numerical implementation. In addition, the VC method has also recently received a relatively favourable assessment in a comparative study confronting various regression-based approaches accommodating varying coefficients (Lucchetti and Valentini 2024). Aside from the ability to give assessments as to whether males or females are more exposed to cyclical fluctuations, knowledge of male and female Okun coefficients that are internally consistent with whole-economy information permits a more informed conduct of short-run stabilization policy.

The remainder of the paper comprises three other sections, which in turn expound the method (Section 2), demonstrate it for the gap version of Okun's law applied to the Group of Seven (G7) economies for the recent thirty years (Section 3), and conclude (Section 4).

2 Disaggregation framework

Gender-specific formulations of Okun's law are motivated by an effort to gauge, and compare, how male and female unemployment co-vary with output, which stipulates their position on the left-hand side of the Okun equation. Okun (1962) formulated three approaches, two of which have later been adopted in research on the unemployment-output cosensitivity, and are known as the gap version and the difference version. The disaggregation is first exposited for the more general gap version and then briefly exposited for the difference version. The more general gap version relates in a regression manner the unemployment and output gap that are utilized to embody fluctuations of unemployment and output across the business cycle. Their importance for macroeconomic analysis and policy making dates to the 1960 s when US stabilization policy in the Keynesian era reoriented from the achievement of a mere expansion to the realization of potential (Okun 1970, pp. 40–43). This makes the gap version of Okun's law more suited to serve the needs of an active stabilization policy (Okun 1970, pp. 43). There are numerous approaches how these gap variables, measuring the cyclical components of unemployment and output may be technically handled and estimated (e.g. Boďa and Považanová 2023). They can be thought of as deviations from a long-term inherent trend (Congressional Budget Office 2004, pp. 1–2, Watson 2007, p. 143) that is often extracted by a suitable filtering method, such as the Hodrick-Prescott or Christiano-Fitzgerald filter. Unlike the gap version, the difference version reduces the unemployment-output coelasticity to short-term fluctuations in aggregate demand, and this formulation of Okun's law with an emphasis upon the short run is adequate when Okun's law is not deployed for long-term goals of macroeconomic policy, but is intended as a purely descriptive tool of the growth path that an economy takes. In the difference version, the gap variables are replaced as appropriate by temporal changes in the unemployment rate and real output without any reference to underlying long-term components and without necessity to estimate them.[1]

With the *gap version*, a basal economy-wide Okun equation with a time-varying Okun coefficient may take the following form

$$\widetilde{u}_t = a + \beta_t \widetilde{y}_t + \varepsilon_t, \tag{1}$$

where $\widetilde{u}_t$ and $\widetilde{y}_t$ are the unemployment and output gap at time t, a is a constant, β_t is the Okun coefficient at time t, and ε_t is a random innovation that is typically assumed to display white-noise properties with mean zero and variance σ^2. In step with Jalles (2019) and Furceri et al. (2020), the intercept in (1) is time-invariant, and only the Okun coefficient is allowed to vary in time. Given the presumable temporal persistence of the unemployment-output relationship, a reasonable model for the Okun coefficient is a random walk in the form

$$\beta_t = \beta_{t-1} + e_{t-1}, \tag{2}$$

where e_{t-1} is again a white-noise random innovation with mean zero and variance σ_e^2, otherwise uncorrelated with ε_t. In fact, Eqs. (1) and (2) represent an observation equation and a space equation, respectively, and may be econometrically handled in a state-space framework. The time-varying feature of the Okun coefficient accounts conveniently for possible asymmetries or non-linearities that oftentimes transpire in Okunian analyses. In contrast to the conventional Kalman filter employed to estimate systems like that depicted by Eqs. (1) and (2), the VC method devised by Schlicht (1985, 2021) is less sensitive to the choice of initial parameters. No distributional assumption is technically needed, and the moments estimator only necessitates the assumptions highlighted at Eqs. (1) and (2). A more pertinent advantage of the VC method over a state space approach implemented with the Kalman filter is not immediately obvious, but it resides in its economic plausibility when the framework is applied with annual data. The reason being, the innovation e_{t-1} in Eq. (2) precedes temporally the innovation ε_t in Eq. (1). Here a shock realized at time $t-1$ carried by e_{t-1} is fully transmitted into the value of the Okun coefficient β_t before it enters Eq. (1) formulated for time t when another shock ε_t presents itself, and it is sensible to assume that e_{t-1} and ε_t are uncorrelated as one year is frequently enough for shocks to be absorbed. A conventional state space framework would employ e_t in Eq. (2) instead of e_{t-1}, and would require that e_t and ε_t are uncorrelated, which would not be defensible.

[1] In line with convention and this explanation, the unemployment gap is obtained as the unemployment rate less its estimated long-term component (operationalizing the natural rate of unemployment) and the output gap follows as the logarithmized real output less its long term trend (operationalizing its potential level). Whereas the former is in percentage points, the latter owing to the logarithmic transformation is stated as a percentage deviation. Likewise, temporal changes in the unemployment rate measure period-on-period changes in the unemployment rate, and temporal changes in real output are stated as period-on-period changes in the logarithmized real output. In consequence, as before, the former is stated in percentage points, the latter is just a continuously compounded growth rate in percentages.

With a constant intercept a and an Okun coefficient β_t varying over discrete consecutive time instances indexed from 1 to T, optimization criterion of the VC method can be schematically written

$$\underset{\widehat{a},\widehat{\beta}_1,\ldots\widehat{\beta}_T,\widehat{v}_e}{minimize} \quad S(\widehat{a},\widehat{\beta}_1,\ldots\widehat{\beta}_T,\widehat{v}_e)=\sum_t \widehat{\varepsilon}_t^2+\widehat{v}_e\sum_t \widehat{e}_t^2, \tag{3}$$

where S is the penalized sum of squares consisting of two least squares components, viz. $\sum \widehat{\varepsilon}_t^2$, and $\widehat{v}_e \sum \widehat{e}_t^2$. Whereas the former is the sum of squared residuals of the main Eq. (1), the latter is the sum of squared residuals associated with the state equation presented in (2) inflated by the variance ratio $\widehat{v}_e=\widehat{\sigma}^2/\widehat{\sigma}_e^2$ estimated concurrently with the regression parameters. Out of these, the former regulates the goodness of fit, and the latter controls the smoothness of the temporal variation in the Okun coefficient. Hat symbols above coefficients represent estimated quantities or residuals. An iterative gradient procedure was developed in Schlicht (2021, p. 1181) to handle the simultaneous estimation of regression coefficients and variance components. Nonetheless, asymptotically with $T\to\infty$ and Gaussianity assumed for random terms in both Eqs. (1) and (2), the moments estimators arising from program (3) coincide with the respective maximum likelihood assumptions. An advantage of the implementation is that the user must provide initial estimates for neither parameter at the cost of a longer numerical optimization. An implementation of the VC method is available in program gretl in the TVC package provided by the author of the method himself. A certain disadvantage of this implementation is that it is not currently optimal in terms of time complexity as noted by Lucchetti and Valentini (2024, pp. 3537), even though the computational time is absolutely not restrictive for estimating an Okun equation. Furthermore, in a recent study by Lucchetti and Valentini (2024, pp. 3536–3537), out of four approaches to the estimation of linear models with time-varying parameters, the VC method and the Kalman filter apparatus came out best in terms of accuracy in comparison to flexible linear squares and kernel-based techniques. Yet, owing to the minimalist requirements of the VC method on input values to initialize optimization, the VC method is extremely suboptimal in terms of computational time.

In conventional Okunian studies, the economy-wide equation as given in (1) would be modified into two gender-specific Okun equations by replacing the total unemployment gap by the male and female unemployment gaps, $\widetilde{u}_t^m$ and $\widetilde{u}_t^f$, which would yield the following system

$$\begin{aligned}\widetilde{u}_t^m &= a^m+\beta_t^m\widetilde{y}_t+\varepsilon_t^m,\\ \widetilde{u}_t^m &= a^f+\beta_t^f\widetilde{y}_t+\varepsilon_t^f,\end{aligned} \tag{4}$$

with a statistical characterization similar to that pertaining to Eq. (1). Even though the equations in system (4) must obviously be related, they would be estimated separately at the ignorance of contemporaneous correlations between them. An appropriate assumption is that $(\varepsilon_t^m,\varepsilon_t^f)'$ have a zero mean vector and a possibly non-diagonal covariance matrix. Regardless of whether treating the gender-specific equations in system (4) separately (e.g. Evans 2018; Zanin 2018; Kim and Park 2019) or simultaneously (e.g. Hutengs and Stadtmann 2014; Dunsch 2017), the resulting estimates are not conformable to the economy-wide equation given in (1). Unless some additional restrictions are imposed, there is no guarantee that the estimated Okun coefficients β_t^m and β_t^f are informationally consistent and aligned with the economy-wide Okun coefficient β_t.

Apparently, the economy-wide equation given in (1) must arise as a notional average of the gender-specific equations in system (4). Hence, the key element of the disaggregation procedure is a weighting schema applied to equations in system (4) that assures informational equivalence of Eq. (1) and system (4), or – in other words – that system (4) yields Eq. (1). Apparently, this informational equivalence is only secured by time-variant weights w_t^m and w_t^f such that at any time t the weighted gender-specific unemployment gaps yield the total unemployment gap, and the weights themselves are restricted by a unit sum, hence: $\widetilde{u}_t = w_t^m\widetilde{u}_t^m + w_t^f\widetilde{u}_t^f$, and $1 = w_t^m + w_t^f$. Given $\widetilde{u}_t$, $\widetilde{u}_t^m$, and $\widetilde{u}_t^f$, as inputs, the weights are computable as $w_t^m = (\widetilde{u}_t - \widetilde{u}_t^f)/(\widetilde{u}_t^m - \widetilde{u}_t^f)$, and $w_t^f = (\widetilde{u}_t^m - \widetilde{u}_t)/(\widetilde{u}_t^m - \widetilde{u}_t^f)$. In a similar vein, the total unemployment rate may be portrayed as a weighted average of male and female unemployment rates, with male and female shares in the total labour force used as weights. However, in the present weighting schema, it is not assured that both weights are non-negative, which flows from the possibly different signs of the gender-specific gaps. When in (4) the male Okun equation is multiplied by w_t^m and the female Okun equation by w_t^f, and both equations are summed, the resulting equation reads

$$w_t^m\widetilde{u}_t^m + w_t^f\widetilde{u}_t^f = (w_t^m a^m + w_t^f a^f) + (w_f^m\beta_t^m + w_t^f\beta_t^f)\widetilde{y}_t + (w_t^m\varepsilon_t^m + w_t^f\varepsilon_t^f) \quad (5)$$

Since the variable on the left-hand side is by definition the unemployment gap $\widetilde{u}_t$, Eqs. (1) and (5) are identical as long as $a = w_t^m a^m + w_t^f a^f$, $\beta_t = w_t^m\beta^m + w_t^f\beta_t^f$, and $\varepsilon_t = w_t^m\varepsilon_t^m + w_t^f\varepsilon_t^f$.[2] However, the economy-wide Okun coefficient can be restated as

$$\beta_t = w_t^m\beta_t^m + w_t^f\beta_t^f = w_t^m\beta_t^m + (1 - w_t^m)\beta_t^f = \beta_t^f + w_t^m(\beta_t^m - \beta_t^f) = \delta_t^0 + \delta_t^1 w_t^m \quad (6)$$

where $\delta_t^0 = \beta_t^f$ and $\delta_t^1 = \beta_t^m - \beta_t^f$. As with the economy-wide Okun coefficient, it is plausible to assume that both δ_t^0 and δ_t^1 (or, put differently, gender-specific Okun coefficients) evolve as random walks and adjust slowly to changes in the environment. This suggests a two-step procedure:

- First, the economy-wide equation is estimated with a constant intercept and an autoregressive Okun coefficient β_t, as described by Eqs. (1) and (2). Instead of the moment or maximum likelihood estimator developed by Schlicht (1985, 2021), the system can be stated as a dynamic linear model and estimated with the use of the Kalman filter.

[2] It might be tempting to restate Eq. (5) as $\widetilde{u}_t = a + \beta_t^m\,[w_t^m\widetilde{y}_t] + \beta_t^f\,[w_t^f\widetilde{y}_t] + \varepsilon_t$ and estimate it with the variables in square brackets considered as regressors, but this equation is not operable owing to the perfect collinearity introduced by the nature of the weights w_t^m and w_t^f.

- Second, the estimated time-varying Okun coefficient β_t is regressed upon the weight for males w_t^m with an autoregressive intercept and an autoregressive slope as in (6). Again, Schlicht's method or the Kalman filter may be applied to that end.[3] Whilst the intercept coincides with the female Okun coefficient, the male Okun coefficients may be estimated as the sum of the intercept and the slope. However, using estimates as the regressand in the second step instead of actual (unobserved) Okun coefficients induces heteroskedasticity commensurate with standard errors of the Okun coefficients estimated in the first step. To address the issue, a weighted-least-squares approach recommended by Saxonhouse (1976) may be applied.[4]

And while this discussion has centred on the VC method or the Kalman filter, in fact any method supplying credible estimates equipped with standard errors is reasonable, but it is obviously desirable that it is applied consistently both in the first and second step.

To justify the second step, the regression in the second step can be represented as

$$b_t = \delta_t^0 + \delta_t^1 w_t^m + \gamma_t, \quad \delta_t^0 = \delta_{t-1}^0 + v_{t-1}^0, \quad \delta_t^1 = \delta_{t-1}^1 + v_{t-1}^1 \tag{7}$$

where $\mathrm{b_t}$ is the estimated Okun coefficient, γ_t, v_{t-1}^0 and v_{t-1}^1 are mutually uncorrelated random innovations with zero means and variances σ_γ^2, $\sigma_{v_0}^2$ and $\sigma_{v_1}^2$, respectively. Hence, the second-step regression implies for the gender-specific Okun coefficients that

$$\beta_t^f = \beta_{t-1}^f + v_{t-1}^0, \beta_t^m = \beta_{t-1}^m + \left(v_{t-1}^0 + v_{t-1}^1\right) \tag{8}$$

which reveals that the female and male Okun coefficients update (absolutely change) with variances $\sigma_{v_0}^2$ and $\sigma_{v_0}^2 + \sigma_{v_1}^2$, respectively, and that their updates are positively related with covariance σ_{v0}^2 and correlation $\sigma_{v0}\left(\sigma_{v0}^2 + \sigma_{v1}^2\right)^{-0.5}$. The male Okun coefficient displays higher variability since male shares in the labour force are utilized as regressors in Eq. (7).

For the *difference* version, it only suffices to replace gap variables $\widetilde{u}_t$ and $\widetilde{y}_t$ in (1) by first differences, say $\Delta \mathrm{u_t}$ and $\Delta \mathrm{y_t}$, which leaves the entire disaggregation framework intact. With all other notation retained and no modifications to the assumptions, the corresponding economy-wide Okun equation (observation equation) and the random walk equation for the Okun coefficient (state equation) now take the form

$$\Delta u_t = a + \beta_t \Delta y_t + \varepsilon_t, \quad \beta_t = \beta_{t-1} + e_{t-1} \tag{9}$$

[3] A technical implementation of Schlicht's VC method with a time-varying intercept only requires equipping the objective function in Eq. (3) with another penalty term reflecting the adaptation of the intercept over time.

[4] This second step is formally described by Eq. (7) presented a few lines later. Equation (7) can be easily modified into a form that corrects for heteroskedasticity. In practice this means estimating a transformed equation $\mathrm{b_t}/\mathrm{se}(\mathrm{b_t})=\delta_t^0 \cdot 1/\mathrm{se}(\mathrm{b_t})+\delta_t^1 \cdot w_t^m/\mathrm{se}(\mathrm{b_t})$, where $\mathrm{se}(\mathrm{b_t})$ is the standard error associated with $\mathrm{b_t}$. Besides relying on transformed variables, this regression has no intercept. Another approach might be based on using estimated feasible generalized least squares advocated by Hanushek (1974).

Once the equation has been estimated using of a method providing estimates of the Okun coefficient alongside their standard errors, the weight for males is determined by the analogical formula as before, viz. w_t^m= (Δu_t–Δu_t^f)/(Δu_t^m –Δu_t^f), where Δu_t^m and Δu_t^f are first differences in the male and female unemployment rates, respectively. The estimated Okun coefficient is then regressed upon the computed weight for males with allowing a time-varying autoregressive pattern in both the intercept and slope. Whilst the female Okun coefficient is identified as the estimated intercept, the male Okun coefficient ensues as the sum of the estimated intercept and the estimated slope.

A drawback of the proposed disaggregation method is that it does not lend itself to modest constant-parameter set-ups since the method relies on the variability contained in the temporal trajectory of the economy-wide Okun coefficient β_t and attributes it to male and female Okun coefficients β_t^m and β_t^f in confrontation with the variability contained in the weights w_t^m. This is impossible when the economy-wide Okun coefficient is assumed constant or identified in the process of fitting as constant.

Finally, for the sake of completeness, it must be said that the present framework is not alone to handle time-varying features of Okun's law. Rolling regressions (e.g. Zanin and Marra 2012; Ibragimov and Ibragimov 2017; Michail 2019) or regression splines (e.g. Zanin and Marra 2012; Zanin 2018) used to be utilized even in the recent past, even though these are heuristic in nature as they impose ad hoc flexibility or constraints upon the temporal patterns embedded in Okun coefficients. For instance, Okun coefficients estimated through rolling regressions may show erratic dynamics suggesting that annual changes in Okun coefficients are exposed to disturbances that go beyond standard (i.e., independently and identically distributed) shocks. By contrast, those estimated through regression splines may display implausible oversmoothed trajectories. The present framework as given in Eqs. (1) and (2) or model (9) is in essence structural and superior as it presumes for the Okun coefficient random walk behaviour and slow adjustments to changes in economic conditions, which makes the entire estimation of Okun's law more realistic, not only as a descriptive tool, but also for the needs of stabilization policy. To explain, one of early uses of Okun's law is to estimate real output costs due to cyclical fluctuations in unemployment (e.g., Hibbs 1987, p. 50), or to answer questions such as what growth rate an economy must attain (above potential) in order to prevent unemployment from rising (e.g., Nguyen and Siriwardana 1988, p. 16). Effective conduct of stabilization policy requires up-to-date information on the current strength of Okun's law, which is communicated by an estimated trajectory of the Okun coefficient at its end point. A full estimated trajectory can also be utilized retrospectively to explain the ever-present varying effects of stabilization policy actions in the past. Certainly, constant-parameter approaches that are built on average coefficients over a historical period fail to provide this information. Likewise, rolling regressions or regression splines may induce odd dynamics in Okun's law since the former leave annual changes in the Okun coefficient free and unconstrained, whereas the latter may be overly restrictive. Therefore, a structural model imposing slow and not overly restricted variation in the Okun coefficient is inevitably preferable. Schlicht's VC method is a viable alternative to handle its estimation.

3 Demonstration

Using the gap version of Okun's law, the proposed approach is illustrated for the G7 economies (Canada, Germany, France, Italy, Japan, the UK, and the USA). The time frame examined encompasses 32 years from 1991 to 2022. The data for the illustration were sourced from the Word Bank Open Data platform (https://databank.worldbank.org). The Hodrick-Prescott filter with the usual value of the smoothing parameter 100 was employed in accord with the suggestion of Kaiser and Maravall (1999) to extend the time series by four backcasts and forecasts at end-points prior to the filtering. In spite of the perpetual critiques and cheering-up countering apologies (Hamilton 2018; Jönsson 2020; Phillips and Shi 2021), the Hodrick-Prescott filter was employed owing to its general acceptance and proliferation in Okunian studies (Boďa and Považanová 2025, p. 27). The Hodrick-Prescott filter was also adopted in conjunction with the gap version of Okun's law by Ball et al. (2017, 2019) that represent recent leading studies in this field of research. Based on the visual exploration of the estimated gap variables, recession dummies were introduced into Eq. (1) around the COVID-19 period to absorb one-off shocks to Okun's law in response to fears raised by Russnak et al. (2023). The inclusion of COVID-19 recession dummies for 2020 applied to all the seven economies. In addition, recession dummies for 2009 to address the timing of the Great Recession were added for Germany and Japan. Of course, these shocks would be detected by the VC method, but for policy purposes it is advisable to separate ephemeral shocks from general tendencies of development. The R program was employed for the analysis in conjunction with program gretl where the TVC package originated by E. Schlicht is available (Schlicht 2022).

The analysis juxtaposes estimates of time-varying Okun coefficients obtained with the conventional approach and the disaggregation method. The former applies the three equations presented in (1) and (4) separately where no consistency is assured between gender-specific Okun coefficients and the economy-wide Okun coefficients. The latter applies a two-step procedure where the gender-specific Okun coefficients are derived from the economy-wide Okun coefficients by requiring some sort of an "accounting" match. For the sake of completeness, Okun coefficients are also estimated under a constant-parameter set-up. The results are presented both in a pictorial format of Fig. 1 and in a tabular format of Tables 1, 2 and 3.

The left-hand portion of Fig. 1 displays trajectories of Okun coefficients estimated by the conventional approach with separate regressions run for the economy, males and females without any heed paid to internal consistency. In contrast, the right-hand part of Fig. 1 exhibits corresponding estimates facilitated by the disaggregation principle. In order to facilitate a better comparison between conventional and disaggregate gender-specific estimates of Okun coefficients, trajectories for the same economy are drawn with an identical scale of the vertical axis. The results in either case evince time-varying patterns and often trend-like features in the trajectories of Okun coefficients. Gradual changes of trends in the visualized trajectories or persistent patterns attest to the adequacy of the random walk assumptions embodied by Eq. (2). It is not reported graphically or elseways in the text, but approximate 95-% confidence bands indicate that for Germany, France, the UK and the USA there are occasional

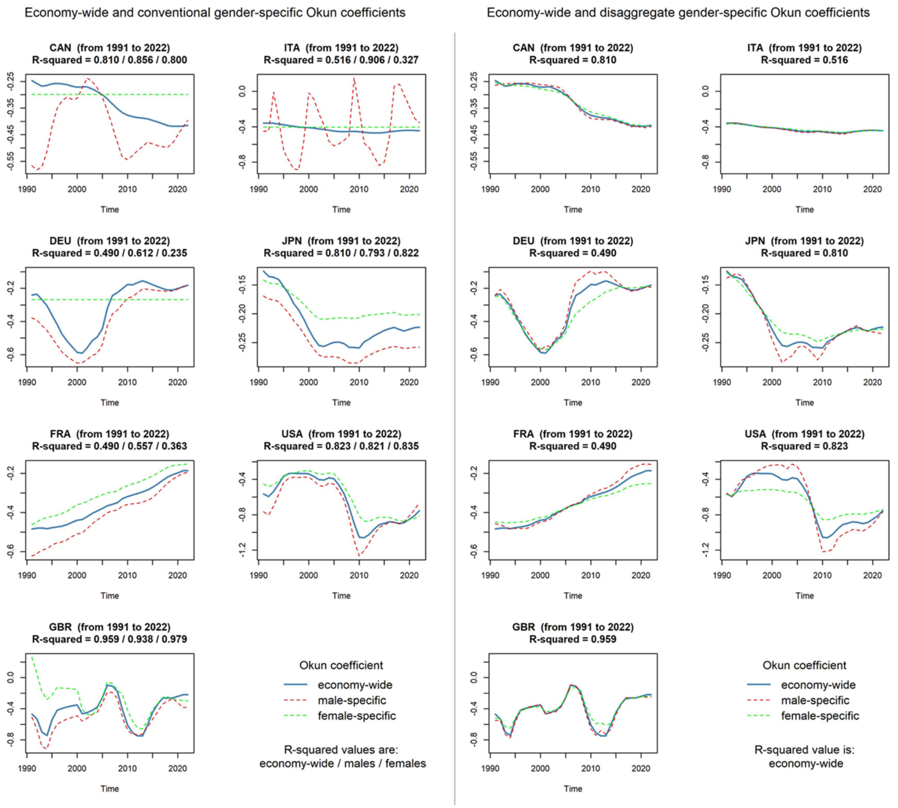

Fig. 1 Comparison of the conventional and disaggregate method for a time-varying set-up

Table 1 Okun coefficients estimated under a constant set-up

Country	Economy-wide		Male-specific		Female-specific	
	β	R^2	β	R^2	β	R^2
CAN	–0.308***	0.773	–0.453***	0.777	–0.298***	0.800
DEU	–0.286**	0.300	–0.384***	0.461	–0.268**	0.235
FRA	–0.373***	0.413	–0.433***	0.463	–0.317**	0.284
GBR	–0.392***	0.749	–0.482***	0.772	–0.244***	0.606
ITA	–0.438***	0.489	–0.449***	0.535	–0.405***	0.327
JPN	–0.204***	0.727	–0.236***	0.734	–0.183***	0.781
USA	–0.590***	0.678	–0.691***	0.656	–0.498***	0.728

The reported estimates are based on Eqs. (1) and (4) handled under a constant set-up, in which the Okun coefficient was assumed constant (hence: $\beta_t = \beta$ for each t). Ordinary least squares were applied to each equation separately. A total of 32 observations were available in each case

Legend: Significance labels respect the notational convention: *** for p-values ≤0.001, ** for p-values ≤0.01, * for p-values ≤0.05, • for p-values ≤0.1, and ns (non-significant) otherwise

Table 2 Average conventional Okun coefficients estimated under a time-varying set-up

Country	Economy-wide		Male-specific		Female-specific	
	Mean of β_t	R^2	Mean of β_t	R^2	Mean of β_t	R^2
CAN	–0.331***	0.810	–0.427***	0.856	–0.298***	0.800[c]
DEU	–0.311*	0.490	–0.387*	0.612	–0.268***	0.235[c]
FRA	–0.356**	0.490	–0.413**	0.557	–0.298**	0.363
GBR	–0.417**	0.959	–0.510*	0.938	–0.276 ns	0.979
ITA	–0.428***	0.516	–0.421 ns	0.906	–0.405***	0.327[c]
JPN	–0.218***	0.810	–0.247***	0.793	–0.191***	0.822
USA	–0.645*	0.823	–0.711•	0.821	–0.580*	0.835

The reported estimates are based on Eqs. (1) and (4) as presented in the text. Schlicht's VC method was applied to each equation separately. Significances are merely approximate as they were determined simply by confronting mean values and standard deviations of estimated Okunian trajectories. A total of 32 observations were available in each case except the UK where the time frame for available gender-specific unemployment rates was shorter with 29 observations

Legend: The superscript symbol [c] indicates that a constant trajectory was identified (and is displayed as a horizontal line in the left-hand side of Fig. 1). Significance labels respect the notational convention: *** for p-values ≤ 0.001, ** for p-values ≤ 0.01, * for p-values ≤ 0.05, • for p-values ≤ 0.1, and ns (non-significant) otherwise

Table 3 Average disaggregated Okun coefficients estimated under a time-varying set-up

Country	Economy-wide		Second-stage R^2	Male-specific	Female-specific
	Mean of β_t	R^2		Mean of β_t	Mean of β_t
CAN	–0.331***	0.810	0.997	–0.332***	–0.330***
DEU	–0.311*	0.490	0.989	–0.282•	–0.337*
FRA	–0.356**	0.490	0.998	–0.345**	–0.363***
GBR	–0.417**	0.959	0.954	–0.430*	–0.397**
ITA	–0.428***	0.516	0.995	–0.432***	–0.414***
JPN	–0.218***	0.810	0.996	–0.224***	–0.214***
USA	–0.645*	0.823	0.996	–0.640•	–0.661***

The reported estimates are based on Eq. (1) for economy-wide Okun coefficients and on the two-stage disaggregation framework with the use of Schlicht's VC method in each case as described in the text. Significances are merely approximate as they were determined simply by confronting mean values and standard deviations of estimated Okunian trajectories. A total of 32 observations were available in each case

Legend: Significance labels respect the notational convention: *** for p-values ≤ 0.001, ** for p-values ≤ 0.01, * for p-values ≤ 0.05, • for p-values ≤ 0.1, and ns (non-significant) otherwise

instances when the Okun coefficient is statistically insignificant.[5] R-squared values show a similar degree of variation as is typical in other studies (e.g. Ball et al. 2017, p. 1431) and reflect the regularity of unemployment-output comovements over the business cycle that differs naturally across countries. One would expect to discern for

[5] At first glance, this may be striking as these are advanced economies for which Okun's law has been estimated and reassessed most extensively. There is a consensus that in these economies Okun's law holds, if with strength varying over time. However, these approaches are typically based on constant coefficients or rely on rolling regressions where uncertainty associated with estimating a single average value over a longer period is lower than with that associated with estimating a whole trajectory. In fact, this pattern is not uncommon for approaches with time-varying coefficients as also follows from the demonstration for the US economy by Lucchetti and Valentini (2024, Fig. 7).

conventional estimates in the left-hand part of Fig. 1 that male and female Okun coefficients – as follows from the considerations around Eq. (5) – would yield economy-wide Okun coefficients on average, which is not always the case. For instance, for Canada, Germany or Japan economy-wide Okun coefficients happen to deflect outside the band shown by gender-specific trajectories. Yet, an average, in the traditional sense conceived as a convex linear combination, cannot go beyond the minimum or maximum value. For Italy, male Okun coefficients display some odd kind of cyclical regularity, which is not observable in the economy-wide counterparts. These aspects are inadvertently masked in Okunian research that is dominated by constant-parameter Okun equations. By contrast, the right-hand side of Fig. 1 displays more credible gender-specific Okunian trajectories when they are brought into confrontation with economy-wide Okun coefficients. Typically, the disaggregated gender-specific Okun coefficients track closely the economy-wide Okun coefficients. In Italy and Japan, for the most period, males are clearly more sensitive to output fluctuations than females are, and in Germany, the sensitivity of females is for the most period higher than that of males. Albeit in some cases, the differences in gender-specific Okun coefficients are somewhat subtle, it is obvious that around the Great Recession of 2008–2009 the trajectories changed or reshuffled, and the unemployment-output nexus suffered from a structural break.

Of course, it is nothing unexpected that Fig. 1 exhibits diverse temporal patterns of Okun coefficients differing across the economies as it has long been accepted that economic laws change or evolve and may be exposed to instabilities (e.g., Keynes 1971, pp. 285–286, Okun 1980, pp. 166, 168). Changing patterns were also observed for Okun's law four decades ago (e.g., Thurow 1984, p. 9, Nguyen and Siriwardana 1988). The upward trending Okun coefficients for France (indicating that Okun's law declined gradually in strength), the downward trending Okun coefficients for Italy or Canada (suggesting that Okun's law slowly increased in magnitude), or rather wave-like patterns for other economies are triggered by macroeconomic, labour market and wider institutional factors that barely remain fixed over a longer period of time. Yet, the ambition of this paper is not to seek formal explanations for these changes as the input to the literature is methodological.

Tables 2 and 3 summarize the estimated time-varying trajectories of Okun coefficients by their average values over the entire period so that they are readily comparable with the estimated constant Okun coefficients shown in Table 1. Since time-varying coefficients permit greater flexibility than constant coefficients do, the R-squared values in Table 2 or 3 are higher than those in Table 1. It should be noted that only in three cases a constant trajectory of the Okun coefficient was identified by the VC method, which happened only for the female Okun coefficient for Canada, Germany and Italy. Hence, in these three cases the estimated coefficients and R-squared values are in Tables 1 and 2 identical since here a time-varying-coefficient model collapses now into a constant parameter model.

Table 1 gives an impression that male unemployment is more cosensitive with output over the business cycle than female unemployment is. The reason being, the estimated male Okun coefficients are all greater in absolute magnitude than female Okun coefficients. In addition, the estimated Okun coefficients in Table 1 for each economy follow nicely a reasonable ordering by magnitude, viz. male Okun coefficients < economy-wide Okun coefficients < female Okun coefficients (the lower and more distant from zero an Okun coefficient is, the stronger is Okun's law). Okun equations are estimated in this direction of research on Okun's law with constant coefficients, and, when arranged in a table, nothing is indicative of an anomaly. Only one example when a tabular presentation of results signals some structural inconsistence is known to the authors, which is Ben-Salha and Mrabet (2019, Table 1) where for Tunisia the estimated economy-wide Okun coefficients goes slightly outside the range of the estimated gender-specific Okun coefficients. Nonetheless, this discrepancy is concealed in a bulk of statistical output. An almost identical pattern is also exhibited in Table 2 for mean trajectories of Okun coefficients where the only exception is Italy, where the male Okun coefficient is found to be insignificant. The said irregularity is just a consequence of the erratic trajectory for the male Okun coefficient exhibited in Fig. 1 as noted earlier.

As the first stage of the disaggregation procedure is the estimation of the economy-wide Okun coefficient in a usual manner, the economy-wide part of the results in Table 3 is identical to the results in Table 2. The differences emerge now in the second stage where the gender-specific Okun coefficients are extracted from the first-stage economy-wide estimates. Since the second-stage regression Eq. (7) has both coefficients time-varying, it is no wonder that the R-squared values in Table 3 are high and attest to a strong fit. However, now the average trajectories of gender-specific Okun coefficients average roughly to economy-wide coefficients, not being very distinct from them. This is in accord with the display of Table 2 that indicates that the frequently acclaimed heightened sensitivity of males to the business cycles may be exaggerated and on average males and females are equally cosensitive with output fluctuations over the business cycle as far as their unemployment is concerned.

This paper is actually intended neither to compare the unemployment-output nexus across the G7 economies nor to attempt an explanation for the differentiated success of Okun regressions (measured by their R-squared values) and the differences in the size of Okun's law (reflected in estimated Okun coefficients). Yet, the reasons for this diverse performance stem from different labour market conditions, institutional environments, structural frameworks or policy actions during the investigated period of three decades in the G7 countries. Three countries–Germany, Japan, and France–are selected as examples in order to put the graphical evidence of Fig. 1 and the numerical report of Tables 1, 2, and 3 into a context.

- The Okun equations fitted for Germany exhibit generally a poor fit with the lowest R-squared value 0.300 in Table 1 under a constant set-up and an R-squared value of 0.490 in Table 2 under a time-varying set-up. Germany was brought to the forefront of attention as a highly cited case study of an economy with flexible labour markets that responded only mildly to the Great Recession whilst German's output declined considerably, which came to be known as the "German labour market miracle" (Rinne and Zimmermann 2012; Burda and Seele 2020). Whilst retaining a relatively strong degree of job protection, labour market reforms introduced between 2003 and 2005, referred to as the "Hartz reforms", promoted flexible forms of employment (fixed-term contracts, temporary agency work), set activation schemes to motivate unemployed people to find employment (Fujita and Gartner 2014, pp.

22–23). Furthermore, for more than one third of the period, between 2005 and 2017, German unemployment maintained a steadily decreasing path in the face of increasing and relatively high labour costs, whilst output consistently rose (Schneider and Rinne 2019, pp. 1, 8). For one thing, Germany managed to develop an institutional framework and automatic stabilizers that increase flexibility and that attenuate the mechanism behind Okun's law. For another thing, a considerable part of the period was void of any turbulences, which is also readable from the estimated time-varying trajectories from 2010 in Fig. 1. In consequence, Okun's law has a lower descriptive power for the period in question and the unemployment-output corresponsiveness is comparatively feebler with an economy-wide estimate of the Okun coefficient of –0.286 or –0.311 in Tables 1, 2 and 3, depending on the set-up.

- Incidentally, the explored period 1991–2022 coincides with the three lost decades in the history of Japanese economic development, during which Japan sustained a protracted era of resilient deflation and sluggish economic growth (Betts 2021) that is sometimes attributed to crippled productivity (Hayashi and Prescott 2002) or even to structural problems and the lost actionability of stabilization policy (Yoshino and Taghizadeh-Hesary 2017, Chapter 1). The estimated economy-wide Okun coefficient for the Japanese economy reported in Tables 1, 2, and 3 is comparatively lowest amongst the G7 economies; that is –0.204 or –0.218. The small unemployment-output responsiveness hints to some level of rigidity in the Japanese labour market that is visible in a lowered degree of sensitivity of both unemployment and output to output variation. This rigidity is epitomized in unemployment trends in Japan during the Great Recession when the increase in unemployment was notably softer than in other countries (Cazes et al. 2013, p. 9), which with the classification of Japan as a country with possibly constant Okun's law. One of the reasons may be a specific culture of the Japanese labour market with an entrenched position of life-time employment or the seniority-wage system (Fujimoto 2024), the former resulting in tiny flows across the labour market, whereas the latter posing ceilings for productivity rises as older employees reached limits of job skill development. Finally, Japan faces population ageing and labour force shortages that jeopardize the stability of the social security system. An attempt to address these issues triggered "the new trinity reform of labour markets" put forward in 2023 (Zou 2024), which is now beyond the investigated period.
- The estimated Okun coefficients in France shown in Fig. 1 monotonously rose towards zero over the entire period 1991–2022, suggesting thus continually decreasing strength of Okun's law. The French economy in the 1970s and 1980s suffered from consistently rising chronic unemployment (Lombard 1994, p. 53), and unemployment persisted at high levels in the 1990s (Saint-Paul 2004, p. 50). Malinvaud (1986, p. S213) attributed this development to both the stagnating global competitiveness of Western Europe and the insufficient activism and unwillingness of governments to address this problem. Moghadam (1995, pp. 16–37) pointed to the inflexibility of the French labour market, and as specific causes she catalogued high employment costs (made up of a high minimum wage and high social security contributions for employers), downward wage rigidity, generous unemployment benefits, and strictness of employee protection, but also structural factors resulting from the skills mismatch. Since the 1990s, the French

labour market has undergone a series of transformative measures aiming at a higher flexibility. Labour market policies in the 1990 s focused lowering labour cost and shortening the work-week (Gazier and Petit 2007, pp. 1027, 1045), and in the next decade the policy initiative shifted to reduce labour costs for low-paid (low-skilled) jobs by cutting social contributions for employers and to de-tax overtime hours in order to boost labour supply (Marchand and Minni 2019, p. 97, Askenazy 2022, p. 2). During the presidency of F. Hollande and E. Macron, French reforms sought to retain strong government involvement in labour market policies, simultaneously promoting higher market flexibility and individualization; that is, some form of "flexicurity". The reform initiatives included substantial changes in vocational training (Gazier 2019, p. 331). The reforms were implemented gradually throughout the 1990 s until the 2010 s, and their effects are discernible in the monotonously decreasing strength of Okun's law.

The estimated economy-wide Okun coefficients obtained under a time-varying set-up reported in Tables 2 and 3 are not altogether different from those reported by other studies for the G7 economies in the past decade; that is, Ball et al. (2017, 2019), Jalles (2019), Furceri et al. (2020). All these four studies relied on the gap version of Okun's law in the style of Eq. (1), which warrants some amount of comparability. Table 4 juxtaposes economy-wide Okun coefficients estimated in this paper as mean time-varying trajectories with static (i.e. constant-parameter) estimates of Okun coefficients reported by Ball et al. (2017, 2019), Jalles (2019), Furceri et al. (2020).[6] As these previous studies utilized less recent time frames to estimate Okun's law, the present estimates may be deemed as their update. It should be noted that not only is it difficult to identify other comparable studies, but there is actually no recent or older relevant study that would estimate gender-specific Okun coefficients for the gap version with a focus on the G7 economies. Therefore, the comparison is here limited to economy-wide Okun coefficients only.

Table 4 reveals similar patterns when estimates of Okun coefficients from different studies are brought together and juxtaposed. For instance, Japan is in Table 4 always identified with the feeblest unemployment-output cosensitivity amongst the G7 economies with relatively high R-squared values. In contrast, the comparatively highest Okun coefficient is constantly estimated for the US economy, again with high R-squared values. As a matter of fact, the only ordering shared across the studies is the following arrangement of Okun's law in terms of strength for three G7 countries: USA (universally strongest Okun's law) > UK > Japan (universally weakest Okun's law). Other G7 countries are more or less intermixed across the studies. Another point is that R-squared values in Table 4 are consistently small or lowest for Germany and Italy, which indicates that for these two countries Okun's law manifests itself with less regularity. As already noted, since the time frames of these studies end in 2015 or earlier, whilst the present study utilizes a time frame until 2022, the present estimates also reflect changes and adaptations in Okun coefficients from 2016 to 2022.

[6] Whereas both Jalles (2019) and Furceri et al. (2020) also employed dynamic Okun equations with a time-varying Okun coefficient estimated by Schlicht's VC method, they did not present their statistical summaries, in consequence of which it is not possible to conduct a more thorough comparison.

Table 4 Comparison of estimated economy-wide coefficients with other studies

Country	This study		Ball et al. (2017)		Ball et al. (2019)		Jalles (2019)	Furceri et al. (2020)
	Mean β_t	R^2	β	R^2	β	R^2	β	β
CAN	–0.331***	0.810	–0.443**	0.785	–0.440***	0.771	–0.419***	–0.427***
DEU	–0.311*	0.490	–0.363**	0.461	–0.370***	0.501	–0.318***	–0.381***
FRA	–0.356**	0.490	–0.353**	0.665	–0.315***	0.582	–0.354***	–0.412***
GBR	–0.417**	0.959	–0.357**	0.559	–0.417***	0.637	–0.350***	–0.355***
ITA	–0.428***	0.516	–0.295**	0.301	–0.334***	0.381	–0.199***	–0.227***
JPN	–0.218***	0.810	–0.165**	0.705	–0.171***	0.694	–0.139***	–0.159***
USA	–0.645*	0.823	–0.476**	0.779	–0.518***	0.763	–0.458***	–0.476***

The table reprints mean trajectories of economy-wide Okun coefficients from Tables 2 and 3 alongside respective R-squared values, and compares them with Okun coefficients and R-squared values, if available, from four comparable studies. These studies applied the gap version with annual data to estimate Okun coefficients under a constant set-up. Estimates from Ball et al. (2017, Table 7) relate to the period 1980–2013, those from Ball et al. (2019, Table 1) appertain to the period 1980–2015, estimates from Jalles (2019, Table 1) correspond to the period 1978–2015, whilst those from Furceri et al. (2020, Table 1) describe the period 1978–2014

Legend: Significance labels respect the notational convention: *** for p-values ≤0.001, ** for p-values ≤0.01, * for p-values ≤0.05, • for p-values ≤0.1, and ns (non-significant) otherwise

4 Conclusion

This paper proposes a disaggregative method that allows identification of gender-specific Okun coefficients in a time-varying set-up when the unemployment-output sensitivity is assumed to adjust slowly to changing conditions. Building upon the stylized fact that Okun's law shows temporal variation, the method utilizes information available in the heterogeneity of the national Okun coefficient and the proportional contribution of genders to the unemployment gap in order to retrieve gender-specific Okun coefficients. The proposed disaggregation framework maintains that gender-specific Okun equations must aggregate to the economy-wide Okun equation, which is not appreciated in conventional Okunian research that resorts to estimating gender-specific Okun equations each separately. The motivation comes from the recognition that the conventional approach is not implemented in a fashion that warrants structural consistency between the economy-wide Okun equation and the two gender-specific Okun equations. In a constant-parameter set-up this flaw is often masked and naturally unnoticed, but it may still happen that an economy-wide estimate realizes outside the range determined by gender-specific estimates. This issue becomes apparent with time-varying Okun coefficients as is fully illustrated for the G7 economies reveals for the period 1991–2022. The empirical demonstration proves that the conventional approach may produce male and female Okun coefficients that do not accord with an economy-wide estimate. Nonetheless, the proposed method yields gender-specific Okun coefficients that average to the economy-wide counterpart. The limitation of the method that it only works for a time-varying set-up is not actually restrictive since the empirical demonstration indicates that the assumption of a constant Okun's law is generally implausible, or otherwise the trajectories were horizontal. In addition, the results suggest that the stylized fact that males are more exposed to business cycle (e.g. Hutengs and Stadtmann 2014; An et al. 2022) is not universally true or may change over time. Since the estimated gender-specific Okun coefficients are not found distant from their economy-wide counterpart, the differentiated sensitivity of males and females over the business cycle may be exaggerated. Albeit the disaggregative method is implemented here with the VC modelling approach developed by Schlicht (1985, 2021), it can be actually handled in any framework allowing time-varying parameters, preferably modelled as random walks. Again, the choice of the VC method is barely restrictive as it has recently found favour in Okunian research (e.g. Jalles 2019; Furceri et al. 2020) and offers reasonable statistical inference. Since the VC method generates estimates of regression parameters jointly with their standard errors (or even a full covariance structure), asymptotic arguments may be put to use in order to facilitate approximate confidence estimation or hypothesis testing. Finally, it may be envisaged that some other disaggregative method will be sooner or later put forward in the wake, which will overcome the present proposal. However, it remains a crucial point that the conventional approach of estimating gender-specific Okun coefficients fails on the criterion of internal consistency.

Acknowledgements The authors acknowledge that explanations for Japan provided in the text arose from previous mutual collaboration with Mariana Považanová.

Authors' contributions M.B. developed the concept, performed the analysis, and wrote the manuscript, M.T. participated in the analysis.

Funding Open access funding provided by the Ministry of Education, Science, Research and Sport of the Slovak Republic in cooperation with Centre for Scientific and Technical Information of the Slovak Republic. The paper arose in partial fulfilment of tasks linked with VEGA project # 1/0346/25.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

References

An Z, Bluedorn J, Ciminelli G (2022) Okun's law, development, and demographics: differences in the cyclical sensitivities of unemployment across economy and worker groups. Appl Econ 54(36):4227–4239

Askenazy P (2022) The transformations of the French labor market, 2000–2021 (updated). IZA World Labor 412v2. https://www.doi.org/10.15185/izawol.412.v2

Ball L, Leigh D, Loungani P (2017) Okun's law: fit at 50? J Money Credit Bank 49(7):1413–1441

Ball L, Furceri D, Leigh D, Loungani P (2019) Does one law fit all? Cross-country evidence on Okun's law. Open Econ Rev 30(5):841–874

Belaire-Franch J, Peiró A (2015) Asymmetry in the relationship between unemployment and the business cycle. Empir Econ 48(2):683–697
Ben-Salha O, Mrabet Z (2019) Is economic growth really jobless? Empirical evidence from North Africa. Comp Econ Stud 61(4):598–624
Betts C (2021) How many (more) lost decades? The great productivity slowdown in Japan. MPRA paper #106503. https://mpra.ub.uni-muenchen.de/106503/
Boďa M, Považanová M (2020) Formal and statistical aspects of estimating Okun's law at a regional level. Pap Reg Sci 99(4):1113–1136
Boďa M, Považanová M (2023) How credible are Okun coefficients? The gap version of Okun's law for G7 economies. Econ Change Restruct 56(3):1467–1514
Boďa M, Považanová M, Škvor J (2024) Okun's law in the Visegrad Group countries: its regional disaggregation and determinants. Spat Econ Anal 19(4):699-721
Boďa M, Považanová M (2025) A quarter century of Okun's law in scholarly literature. J Knowl Econ 16:17784–17839
Burda MC, Seele S (2020) Reevaluating the German labor market miracle. Germ Econ Rev 21(2):139–179
Cazes S, Verick S, Al Hussami F (2013) Why did unemployment respond so differently to the global financial crisis across countries? Insights from Okun's law. IZA J Labor Policy 2(10):1–18
Congressional Budget Office (2004) A summary of alternative methods for estimating potential GDP. The Congress of the United States, Congressional Budget Office, Washington, D.C.
Dunsch S (2017) Age-and gender-specific unemployment and Okun's law in CEE countries. East Eur Econ 55(4):377–393
Evans A (2018) Okun coefficients and participation coefficients by age and gender. IZA J Labor Econ 7(1):5
Fujimoto M (2024) Will the Japanese long-term employment system continue to be maintained? Japan Labor Issues 8(47):57–62
Fujita S, Gartner H (2014) A closer look at the German labor market miracle. Bus Rev Q 4:16–24
Furceri D, Jalles JT, Loungani P (2020) On the determinants of the Okun's law: new evidence from time-varying estimates. Comp Econ Stud 62(4):661–700
Gazier B (2019) Opportunities or tensions: assessing French labour market reforms from 2012 to 2018. Int J Comp Labour Law 35(3):331–354
Gazier B, Petit H (2007) French labour market segmentation and French labour market policies since the seventies: connecting changes. Économies Et Sociétés, Série Socio-Economie Du Travail, AB 28:1027–1056
Hamilton JD (2018) Why you should never use the Hodrick-Prescott filter. Rev Econ Stat 100(5):831–843
Hanushek EA (1974) Efficient estimators for regressing regression coefficients. Am Stat 28(2):66–67
Hayashi F, Prescott EC (2002) The 1990s in Japan: a lost decade. Rev Econ Dyn 5(1):206–235
Hibbs DA Jr (1987) The American political economy: Macroeconomics and electoral politics. Harvard University Press, Cambridge
Huang H-C (River), Lin S-C (2008) Smooth-time-varying Okun's coefficients. Econ Model 25(2):363–375
Hutengs O, Stadtmann G (2014) Age- and gender-specific unemployment in Scandinavian countries: an analysis based on Okun's law. Comp Econ Stud 56(4):567–580
Ibragimov M, Ibragimov R (2017) Unemployment and output dynamics in CIS countries: Okun's law revisited. Appl Econ 49(34):3453–3479
Jalles JT (2019) On the time-varying relationship between unemployment and output: what shapes it? Scott J Polit Econ 66(5):605–630
Jönsson K (2020) Cyclical dynamics and trend/cycle definitions: comparing the HP and Hamilton filters. J Bus Cycle Res 16(2):151–162
Kaiser R, Maravall A (1999) Estimation of the business cycle: a modified Hodrick-Prescott filter. Span Econ Rev 1(2):175–206
Keynes JM (1971) The collected writings of John Maynard Keynes. Volume XIV. The general theory and after. Part II. Defence and development (D. Moggridge, Ed.). Cambridge University Press
Kim MJ, Park SY (2019) Do gender and age impact the time-varying Okun's law? Evidence from South Korea. Pac Econ Rev 24(5):672–685
Lombard M (1994) Analysing the persistence of unemployment: the French experience. Int Contrib Labour Stud 4:53–72
Lucchetti R, Valentini F (2024) Linear models with time-varying parameters: a comparison of different approaches. Comput Stat 39:3523–3545
Malinvaud E (1986) The rise of unemployment in France. Economica 53(210):S197–S217

Marchand O, Minni C (2019) The major transformations of the French labour market since the early 1960s. Economie et Statistique / Econ Stat, 510–511–512, 89–107
Michail NA (2019) Examining the stability of Okun's coefficient. Bull Econ Res 71(3):240–256
Moghadam R (1995) Why is unemployment in France so high? In: Masson PR (ed) France: Financial and real sector issues. International Monetary Fund, Washington
Nguyen DT, Siriwardana AM (1988) The relationship between output growth and unemployment: a re-examination of Okun's law in Australia. Aust Econ Rev 21(1):16–27
Okun AM (1970) The political economy of prosperity. The Brookings Institution, Washington, D.C.
Okun AM (1980) Postwar macroeconomic performance. In: Feldstein M (ed) The American economy in transition. University of Chicago Press, Chicago, pp 162–169
Okun AM (1962) Potential GNP: Its measurement and significance. In: Proceedings of the Business and Economic Statistics Section of the American Statistical Association, pp 89–104
Phillips PC, Shi Z (2021) Boosting: why you can use the HP filter. Int Econ Rev 62(2):521–570
Rinne U, Zimmermann KF (2012) Another economic miracle? The German labor market and the Great Recession. IZA J Labor Policy 1:1–21
Russnak J, Stadtmann G, Zimmermann L (2023) Does Okun's law suffer from COVID-19? Evidence from Europe and the US. Econ Bus Lett 12(2):165–171
Saint-Paul G (2004) Why are European countries diverging in their unemployment experience? J Econ Perspect 18(4):49–68
Saxonhouse GR (1976) Estimated parameters as dependent variables. Am Econ Rev 66(1):178–183
Schlicht E (1985) Isolation and aggregation in economics. Springer, Berlin
Schlicht E (2021) VC: a method for estimating time-varying coefficients in linear models. J Korean Stat Soc 50(4):1164–1196
Schlicht E (2022) Estimating time-varying coefficients with Gretl using the VC method. Munich Discussion Paper No. 2022–1. Munich: Ludwig-Maximilians-Universität München
Schneider H, Rinne U (2019) The labor market in Germany, 2000–2018. IZA World of Labor
Thurow LC (1984) Dangerous currents: The state of the economy. Vintage Books, New York
Watson MW (2007) How accurate are real-time estimates of output trends and gaps? FRB Richmond Econ Quarterly 93(2):143–161
Yoshino N, Taghizadeh-Hesary F (2017) Japan's lost decade. Springer
Zanin L (2018) The pyramid of Okun's coefficient for Italy. Empirica 45(1):17–28
Zanin L, Marra G (2012) Rolling regression versus time-varying coefficient modelling: An empirical investigation of the Okun's law in some euro area countries. Bull Econ Res 64(1):91–108
Zou F (2024) The 'new trinity' reform of labour markets in Japan. Asia Pac Bus Rev 30(3):577–595. https://doi.org/10.1080/13602381.2024.2320550

Authors and Affiliations

Martin Boďa[1,2] · Michaela Tichá[2]

✉ Martin Boďa
martin.boda@umb.sk; martin.boda@outlook.com

Michaela Tichá
michaela.ticha@ujep.cz

1 Faculty of Economics, Matej Bel University in Banská Bystrica, Tajovského 10, 975 90 Banská Bystrica, Slovak Republic

2 Faculty of Natural Sciences, Jan Evangelista Purkyně University in Ústí nad Labem, Pasteurova 15, 400 96 Ústí nad Labem, Czech Republic