Not Evidence for Baumol's Cost Disease

A replication study of Hartwig (*Journal of Health Economics*, 2008)

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Data Availability: All the data that we use in this replication study were provided by the author of the original study, Jochen Hartwig. The EViews-code to reproduce the results of this replication can be downloaded at IREE's data archive (DOI: 10.15456/iree.2019129.193231).

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Abstract

In his 2008 *Journal of Health Economics* paper, Jochen Hartwig claimed that Baumol's Cost Disease (BCD) theory could explain observed increases in health care expenditures in OECD countries. This paper replicates Hartwig's results and demonstrates that he tested the wrong hypothesis. When one tests the correct hypothesis, Hartwig's conclusions are not supported. Rather than providing evidence in favor of BCD, Hartwig's estimation procedures, when applied correctly, strongly reject BCD as an explanation for health expenditure increases for the OECD data he examined.

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1 Introduction

In a series of papers, William J. Baumol (Baumol, 1967; Baumol, 1993; and Baumol and Towse, 1997) argues that relatively non-productive industries are forced to pay higher wages to match compensation in relatively productive industries. This drives wages above marginal product in the non-productive industries. Over time, these wage costs in excess of productivity in the non-productive sector consume ever-larger shares of GDP, as costs in the non-productive industries are pushed up by productivity increases in the productive sector. This phenomenon, known as Baumol's Cost Disease (BCD), is frequently cited as an explanation for why service industries like health, education, and the arts are becomingly increasingly expensive.

2 Hartwig's Test of BCD

While BCD is consistent with observed increases in health care expenditures, it has been difficult to develop testable hypotheses to confirm its existence. In 2008, Hartwig (2008) published an influential paper [1] in the *Journal of Health Economics* where he claimed to have developed a test for BCD and to have confirmed its existence. Hartwig's test is based around the following idea (Hartwig, page 609): "Baumol's model predicts that wage increases in excess of productivity growth lead to higher HCE [health care expenditure] growth ... So, if we regress the growth rate of (per capita) HCE on the difference between the growth rates of nominal wages per employee and productivity (both averaged over all sectors), we should get a positive and statistically significant coefficient..."

Hartwig tests Baumol's theory using a two-step procedure. He begins by estimating the model,

$$d\log(HCEPC) = \beta_0 + \beta_1 d\log(WSPE) + \beta_2 d\log(GDPR) + \beta_3 d\log(EMP) + \epsilon, \tag{1}$$

where *HCEPC* is health care expenditures per capita, *WSPE* is wages and salaries per employee, *GDPR* is real GDP, and *EMP* is total employment. All the variables are differenced in logs to avoid spurious associations arising from nonstationarity (Hartwig, 2008, page 609). His data consist of country-level data from 19 OECD countries over the years 1971-2003.

In the first step, he tests whether the variables $d\log(WSPE)$, $d\log(GDPR)$, and $d\log(EMP)$ can be combined into a single "Baumol" variable, defined by

$$\begin{aligned} Baumol &\equiv d\log(WSPE) - d\log(PROD) \\ &\equiv d\log(WSPE) - d\log(GDPR) + d\log(EMP). \end{aligned} \tag{2}$$

On the basis of his test results, he concludes that it is legitimate to do this.

In the second step, he tests the coefficient on the $Baumol$ variable in the following regression.

$$d\log(HCEPC) = \beta_0 + \alpha Baumol + \epsilon. \tag{3}$$

Hartwig claims that BCD implies that $\alpha = 1$. He tests $H_0 : \alpha = 1$, fails to reject this hypothesis, and concludes that he has found evidence of the existence of BCD:

[1] At the time of this writing, Hartwig (2008) has been cited 83 times in Web of Science and 230 times in Google Scholar.

> "Proceeding in a general-to-specific manner, we first estimate the influence of these three variables separately in order to test whether the restriction of summing them together to one variable is legitimate. [. . .] For all three estimations, Wald test results [. . .] fail to reject the hypothesis that $C(1) + C(2) - C(3) = 0$ so that we can legitimately combine the three variables into one. Table 2 shows our results for the 'Baumol variable'. We find that Baumol's model of 'unbalanced growth' is strongly supported by the data. In all three specifications, the coefficient of the difference between nominal wage and productivity growth rates is statistically different from zero. As predicted by Baumol's theory, the value of the coefficient is close to one. Again, the Wald test fails to reject the hypothesis that the coefficients are in fact equal to one" (page 610).

Subsequent research has noted that Hartwig's assertion that Baumol's theory implies a coefficient of one on the *Baumol* variable is only true in the limit, when the share of employment in the unproductive sector approaches 100 percent (Columbier, 2012, page 10). Outside of long-run equilibrium, Baumol's theory implies a positive coefficient on the *Baumol* variable (Bates and Santerre, 2013, page 387). Nevertheless, this revision in Hartwig's approach does not alter his ultimate conclusion regarding BCD, because the coefficient on the *Baumol* variable is positive and statistically significant.

3 A mistake in the first step

Given the definition of the *Baumol* variable in Equation (2), it is straightforward to identify a necessary condition for substituting this variable into Equation (1):

In order for

$$d\log(HCEPC) = \beta_0 + \beta_1 d\log(WSPE) + \beta_2 d\log(GDPR) + \beta_3 d\log(EMP) + \epsilon, \tag{1}$$

to be written as

$$d\log(HCEPC) = \beta_0 + \alpha Baumol + \epsilon, \tag{3}$$

where

$$Baumol = d\log(WSPE) - d\log(GDPR) + d\log(EMP), \tag{2}$$

it must be the case that:

$$\beta_1 = -\beta_2 = \beta_3 = \alpha. \tag{4}$$

Replacing β_1 and β_3 with α in Equation (1), and β_2 with $-\alpha$, produces:

$$d\log(HCEPC) = \beta_0 + \alpha \cdot d\log(WSPE) - \alpha \cdot d\log(GDPR) + \alpha \cdot d\log(EMP) + \epsilon. \tag{5}$$

Only if Equation (4) holds can Equation (1) be re-written as

$$\begin{aligned} d\log(HCEPC) &= \beta_0 + \alpha[d\log(WSPE) - d\log(GDPR) + d\log(EMP)] + \epsilon, \\ &= \beta_0 + \alpha Baumol + \epsilon. \end{aligned} \tag{3'}$$

Thus, a necessary condition for Hartwig to combine the three variables into a single $Baumol$ variable is that $\beta_1 = -\beta_2 = \beta_3$. Unfortunately, Hartwig does not test these equalities. Instead, he tests "C(1)+C(2)-C(3)=0". Translated in terms of Equation (1), this equates to testing

$$\beta_1 + \beta_2 - \beta_3 = 0. \tag{6}$$

Hartwig fails to reject Equation (6) and this leads him to conclude that the three variables can be combined into one. This is a mistake. It should be clear that Equation (6) is unrelated to the necessary condition that $\beta_1 = -\beta_2 = \beta_3$. Thus, Hartwig conducts the wrong test.

4 A replication of Hartwig and a correct test

Table 1 reports the results of replicating Table 1 in Hartwig (2008). Our results match his for each of the three estimation procedures: OLS, Cross-section Random Effects, and Time period Random Effects.[2] Note particularly the results of the Wald tests at the bottom of the table. For the OLS procedure, after estimating Equation (1), Hartwig tests $H_0 : \beta_1 + \beta_2 - \beta_3 = 0$. He obtains a sample F statistic of 0.817. The associated p-value is 0.366. Our results exactly match his. However, as noted above, these results do not justify combining the three variables into one. When we conduct the correct test ($H_0 : \beta_1 = -\beta_2 = \beta_3$) we obtain a sample F value of 34.068 with an associated p-value of 0.000. This is very strong evidence that it is not valid to combine the three variables into a single $Baumol$ variable. Similar results follow for the other two specifications in Table 1. Rather than providing evidence in favor of BCD, we argue below that the results from the correct test provide direct evidence against BCD.

5 Is the first step really necessary?

As noted above, Baumol's model implies that wage increases in excess of labor productivity growth are responsible for the rise in health expenditures. Consistent with this hypothesis, he finds that α is positive and significant in the equation below,

$$d\log(HCEPC) = \beta_0 + \alpha Baumol + \epsilon. \tag{5}$$

Table 2 reports the results of replicating Table 2 in Hartwig (2008). Our results again match his for each of the three estimation procedures.[3] Most importantly, we confirm that the estimated coefficient on the $Baumol$ variable (i.e., $d\log(WSPE) - d\log(PROD)$) is positive and highly significant. Given that these results confirm the main prediction of BCD, perhaps we shouldn't be too concerned about the earlier results. Perhaps the first step wasn't really necessary.

We note that Hartwig must have thought the first-stage results were important for his BCD claims, otherwise why report, and emphasize them? As we next demonstrate, Hartwig was correct

[2] Estimated coefficients and t-stats matched exactly. We found some discrepancies in the third decimal point for a couple of the Adjusted R-squared values and one of the Durbin-Watson statistics.

[3] Table 2 does not include the results of testing that the $Baumol$ coefficient equals one. While we can reproduce Hartwig's results, this test is unnecessary. All that Baumol's theory requires is that the coefficient be positive and significant, which it is in all three regressions.

in thinking this.

Consider a regression of the log of health expenditures per capita on (i) the log of nominal wages per employee, (ii) the log of GDP, and (iii) the log of total employment, where we ignore the taking of differences without loss of generality.

$$\log(HCEPC) = \delta_0 + \delta_1 \log(WSPE) + \delta_2 \log(GDPR) + \delta_3 \log(EMP) + \nu. \tag{7}$$

Without any reference to BCD, a reasonable expectation is that $\delta_1 > 0$: As workers' wages increase, one expects an increase in demand for health care, either directly via private expenditures, or indirectly through greater support for public health spending.

Without any reference to BCD, a reasonable expectation is that $\delta_2 < 0$: Holding employment constant, an increase in GDP implies an increase in productivity. As economy-wide productivity increases, one expects capital to replace relatively more expensive labor in health care production, and more efficient capital to replace less efficient capital, so that health care expenditures will fall, holding constant demand.

Finally, and again without any reference to BCD, a reasonable expectation is that $\delta_3 > 0$: Holding constant workers' wages and national GDP, an increase in the workforce increases the number of individuals requiring/demanding health care, further increasing the demand for health care. As table 1 demonstrates, Hartwig's estimates exactly confirm these three expectations.

Further, note that Equation (7) can be rewritten as

$$\begin{aligned}\log(HCEPC) &= \delta_0 + \delta_1 [\log(WSPE) - \log(GDPR) + \log(EMP)] + \nu^* \\ &= \delta_0 + \delta_1 Baumol + \nu^*,\end{aligned} \tag{8}$$

where $\nu^* = (\delta_2 + \delta_1) \cdot \log(GDPR) + (\delta_3 - \delta_1) \cdot \log(EMP) + \nu$. We can solve for the expected value of the OLS estimator of δ_1 in Equation (8).

$$\begin{aligned}E\{\hat{\delta}_1\} = \delta_1 + (\delta_2 + \delta_1) E &\left\{ \frac{\sum (Baumol - \overline{Baumol}) \log(GDPR)}{\sum (Baumol - \overline{Baumol})^2} \right\} \\ + (\delta_3 - \delta_1) E &\left\{ \frac{\sum (Baumol - \overline{Baumol}) \log(EMP)}{\sum (Baumol - \overline{Baumol})^2} \right\}\end{aligned} \tag{9}$$

We will now attempt to sign $E\{\hat{\delta}_1\}$ without making any reference to BCD. From above, $\delta_1 > 0$, $(\delta_2 + \delta_1) \lesseqgtr 0$, and $(\delta_3 - \delta_1) \lesseqgtr 0$, with the latter two inequalities depending on the relative magnitudes of δ_2 and δ_1, and δ_3 and δ_1, respectively. Further, $\rho_{Baumol, \log(GDPR)} < 0$ and $\rho_{Baumol, \log(EMP)} > 0$ by virtue of how the *Baumol* variable is constructed.

Thus, without making any reference to BCD, we can sign the first term in Equation (9) as positive, with the signs of the second and third terms being indeterminate. The only way $E\{\hat{\delta}_1\}$ could be negative is if the latter two terms in Equation (9) are not only negative, but sufficiently negative to dominate the first term. Thus, one can reasonably expect a positive sign for the coefficient of the

Baumol variable without making any reference to BCD.

We now have two hypotheses that can explain the signs of the coefficients of the individual variables in Table 1, and the sign of the *Baumol* variable in Table 2. How could one distinguish between these two hypotheses? It is precisely the first step in Hartwig's procedure that allows one to do that. Evidence in favor of BCD would be $\delta_1 = -\delta_2 = \delta_3$. This is presumably why Hartwig felt the need to have the first step of his two-step procedure. The problem was that he conducted the wrong test. When one conducts the correct test, $H_0 : \delta_1 = \delta_2 = \delta_3$ is strongly rejected, and that constitutes compelling evidence against BCD.

$\delta_1 = -\delta_2 = \delta_3$ is more than just a technical condition for combining three variables into one. It has an economic meaning. If it is true that the causative factor driving increased health care expenditures is the surplus between wages and worker productivity, the source of the surplus shouldn't matter. It shouldn't matter whether the reason there is a surplus of wages over productivity is because wages are "too high", or productivity is "too low". Contributions to the surplus from either source should have equal force in driving up health care expenditures. Rejection of $\delta_1 = -\delta_2 = \delta_3$ indicates that the source of the surplus matters, and that is evidence against Baumol's theory. It suggests that the explanation for the positive coefficient on the *Baumo*l variable lies elsewhere.

6 *Why it is important*

One reason why it is important to correct Hartwig (2008) is that it has had a substantial influence on research in this area. Other studies have commended Hartwig's formulation of a "Baumol" variable and used it in their empirical research. Colombier (2012, page 6) writes: "Hartwig (2008) avoids the shortcomings of the medical-price indices by introducing a so-called "Baumol-variable" to estimate the impact of price increase on healthcare expenditure. As a result, Hartwig's (2008) study does not suffer from the drawbacks emphasized by Cutler et al. (1998) and others. . . ." Bates and Santerre (2013) write: "This study . . . relies on an empirical test proposed by Hartwig (2008) and extended by Colombier . . . " And Medeiros and Schwierz (2013, page 36) write: "In this section, Hartwig's (2008) methodology is used to test empirically the main implication of Baumol's 'unbalanced growth model' . . . " All of these studies interpret a positive and significant coefficient on the "Baumol" variable as evidence in favor of BCD. In so doing, they propagate Hartwig's error.

7 *Conclusion*

In his 2008 *Journal of Health Economics* paper, Jochen Hartwig proposed a test of Baumol's Cost Disease theory as an explanation for increases in health care expenditures in OECD countries. The test proceeded in two steps. First, he defined a "Baumol" variable as "wage increases in excess of labor productivity growth". To determine whether the individual components of the "Baumol" variable (wage increases, productivity increases, employment increases) could be combined into a single variable, he tested a hypothesis for which failure to reject was interpreted as evidence that the individual components could be combined. After obtaining this result, he went on to regress health care expenditures on the "Baumol" variable and found that the coefficient was positive and statistically significant. As a result, he concluded that BCD was a major driver of OECD health expenditure increases.

This paper reproduces Hartwig's results and demonstrates that he tested the wrong hypothesis for combining the individual components into a single Baumol variable. When one tests the correct hypothesis, it is strongly rejected, demonstrating that one cannot combine the individual components into a single "Baumol" variable. This is more than the failure of a technical condition. It means that it is not the surplus of wages over productivity that is responsible for increases in health care expenditures in OECD. The fact that one can force the individual components of the Baumol variable together, and obtain a positive coefficient in an associated *Baumol* regression is not sufficient to provide evidence for Baumol's model. Alternative hypotheses are able to explain this result.

In a recent paper, Atanda, Menclova, and Reed (2018) examined annual health care expenditures for 28 OECD countries over the years 1995–2016. They found no evidence to support the existence of Baumol's Cost Disease (BCD). Their results directly conflict with Hartwig (2008). The fact that the two studies, using similar data, come to opposite conclusions is troubling. This note resolves that conflict by demonstrating that, in fact, both studies reject the BCD hypothesis as an explanation for rising health care expenditures in OECD countries.

Table 1: REPLICATION OF HARTWIG'S TABLE 1: Results for growth rate equations – 'Baumol variable' split

Estimated Equation:

$$d\log(HCEPC) = \beta_0 + \beta_1 d\log(WSPE) + \beta_2 d\log(GDPR) + \beta_3 d\log(EMP) + \epsilon$$

	(1) OLS	(2) Cross-section R.E.	(3) Time period R.E.
$d\log(WSPE)$	1.066	1.064*	1.059*
	(28.557)	(27.561)	(27.155)
$d\log(GDPR)$	−0.339*	−0.351*	−0.308*
	(−3.951)	(−4.049)	(−3.571)
$d\log(EMP)$	0.601*	0.599*	0.588*
	(7.377)	(7.331)	(7.511)
Number of obs.	507	507	507
adj. R^2	0.809	0.799	0.793
SE of regression	0.032	0.031	0.031
D-W	1.830	1.852	1.827
Wald test F-stat (prob.)			
$H_0 : \beta_1 + \beta_2 - \beta_3 = 0$	0.817	0.648	1.318
	(0.366)	(0.421)	(0.252)
$H_0 : \beta_1 = -\beta_2 = \beta_3$	34.068	31.557	33.500
	(0.000)	(0.000)	(0.000)

NOTE: *HCEPC* is health care expenditures per capita, *WSPE* is wages and salaries per employee, *GDPR* is real GDP, and *EMP* is total employment. All variables are differenced in logs to generate growth rates. The estimated equation is given in the top of the table. Coefficient estimates for the three explanatory variables are reported in the first three rows, with t-stats reported in parentheses. The estimate for the constant term is not reported. The data consist of annual, country-level observations from 19 OECD countries over the years 1971-2003. "OLS", "Cross-section Random Effects", and "Time period Random Effects" refer to the following three "pool estimation" procedures in Eviews: pooled OLS, Random Effects with random effects for cross-sections, and Random Effects with random effects for time periods. In all three cases, White's robust estimator for cross-sectional dependence is used to estimate standard errors. A "*" indicates the coefficient is statistically significant at the 1 percent level.

Table 2: REPLICATION OF HARTWIG'S TABLE 2: Results for growth rate equations – 'Baumol variable' unsplit

Estimated Equation:

$$d\log(HCEPC) = \delta_0 + \delta_1 \text{Baumol} + \epsilon$$

	(4) OLS	(5) Cross-section R.E.	(6) Time period R.E.
$d\log(WSPE) - d\log(PROD)$	1.033*	1.016*	1.029*
	(34.763)	(32.763)	(34.204)
Number of obs.	507	507	507
adj. R^2	0.770	0.743	0.757
SE of regression	0.035	0.033	0.034
D-W	1.668	1.787	1.663

NOTE: *HCEPC* is health care expenditures per capita, *PROD* is labor productivity (real GDP per employee) in the overall economy. The first row reports coefficient estimates for the *Baumol* variable (= $d\log(WSPE) - d\log(PROD)$), with t-stats reported in parentheses. The estimate for the constant term is not reported. The data consist of annual, country-level observations from 19 OECD countries over the years 1971-2003. "OLS", "Cross-section Random Effects", and "Time period Random Effects" refer to the following three "pool estimation" procedures in Eviews: pooled OLS, Random Effects with random effects for cross-sections, and Random Effects with random effects for time periods. In all three cases, White's robust estimator for cross-sectional dependence is used to estimate standard errors. A "*" indicates the coefficient is statistically significant at the 1 percent level.

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