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# SOURCES OF PRODUCTIVITY GROWTH DYNAMICS: IS JAPAN SUFFERING FROM BAUMOL'S GROWTH DISEASE?

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This study examines the sources of labor productivity growth dynamics in Japan (1970–2010) and investigates the extent to which Japanese economic performance has been affected by Baumol's growth disease (BGD). We find that BGD silently undermines Japanese economic growth. However, the magnitude is miniscule, and consequently the aggregate labor productivity growth rate has not been decreasing monotonically. We also explore how BGD is arising and why it is small in the Japanese economy. BGD is weak because (1) the positive Baumol growth effect is also working in certain services sectors and (2) BGD is not a durable phenomenon: even if a sector begins to suffer from BGD, it is likely to recover quickly.

**JEL Codes**: L16, O47, O53

**Keywords**: Baumol's growth disease, productivity growth rate decomposition, Japanese economy

## 1. Introduction

This study empirically investigates the sources of productivity growth dynamics in Japan by using the Baumol (1967) model. While this classical model provides insights into macroeconomic performance from a multisectoral perspective, its empirical aspects have not thus far been sufficiently evaluated, especially for Japan. We explore sectoral labor productivity growth and contribution to the aggregate labor productivity growth rate, while also considering industrial structural change (i.e. the change in the sectoral composition of nominal value added and man–hours). By doing so, we investigate whether the Japanese economy is suffering from Baumol's growth disease (BGD).

Baumol (1967) divides the whole economy into progressive sectors, which have a high productivity growth rate, and non-progressive sectors, which have a low productivity growth rate. He explains theoretically that aggregate productivity growth declines monotonically as the nominal value added (or employment) share of the latter expands, which is known as BGD. Studies after Baumol attempted to assess if expansion in a non-progressive sector has a negative impact on macroeconomic performance. These studies consider the expansion of the services sector, also classified as a non-progressive low-productivity sector in most cases, to represent structural change. Whether BGD is a universal phenomenon is inconclusive from the

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existing literature. Some research supports Baumol's prediction (Baumol *et al.*, 1985; Fase and Winder, 1999; Peneder, 2003; Tang and Wang, 2004; Hartwig, 2008, 2011, 2012; Nordhaus, 2008), while other studies present contrary results (Triplett and Bosworth, 2003; Maroto-Sánchez and Cuadrado-Roura, 2009; Dietrich, 2012), or concur with his findings partially (Oh and Kim, 2015).

Indeed, the results of BGD may differ empirically by country, period, and sector, even if the original theory is correct. This fact means that productivity growth dynamics are specific to each country, period, and sector and, accordingly, the implications of the sources and consequences may well differ. Hence, what implications does this model suggest for the Japanese economy? The current study focuses on the sources of labor productivity dynamics to reveal in detail whether the Japanese economy suffers from BGD.

In doing so, it makes at least three contributions to the existing literature. First, we not only extract the magnitude of BGD, but also reveal where, how, and why BGD is arising in Japan. Some studies have extracted BGD by using decomposition analysis for the aggregate labor productivity growth rate. Although they have detected the degree of BGD based on the reallocation effect of labor, they have not explored how and why BGD is arising. In addition, they cover only a single period, such as 1987–98 (Tang and Wang, 2004), 2000–10 (de Avillez, 2012), or 2008–9 (Dumagan, 2013). Sharpe (2010) divides a long-run period into 1973–2000 and 2000–7. However, such a division is still approximate and therefore is an unsuitable period over which to examine the asymptotic nature of BGD. The current study also employs decomposition analysis, but it further explores the mechanism of BGD by dividing the long-run period into consecutive smaller subperiods. Such an approach is required to assess the nature of BGD in Japan, because BGD is explained as a gradual and asymptotic phenomenon.

Second, we introduce a multisectoral perspective into the empirical analysis of the Japanese economy. The Japanese economy has experienced growth and stagnation over time, particularly long-run stagnation with serious deflation since the 1990s. With regard to growth, stagnation, and deflation, the existing literature has focused on aggregate demand (e.g., Yoshikawa, 2007) and supply (e.g., Hayashi and Prescott, 2002), as well as the institutional determinants (e.g., Boyer *et al.*, 2011). While these determinants are important, the diverse performances among industries play a decisive role in shaping macroeconomic performance. Motivated by the rising availability of comprehensive industry-level data in Japan, recent studies have emphasized the increasing heterogeneity of industries and firms (Fukao and Kwon, 2006; Fukao and Miyagawa, 2008; Ito and Lechevalier, 2009; Jorgenson and Timmer, 2011; Fukao, 2012; Morikawa, 2014b).[1] This study

[1]They especially focus on the supply side, with the investigation of total factor productivity (TFP) growth the most popular. Fukao and Miyagawa (2008) indicates that the TFP growth rate differs at the industry and firm levels. Fukao and Kwon (2006) finds that the slow reallocation of resources from less efficient to more efficient firms in the manufacturing sector slows TFP growth, while Fukao (2012) emphasizes that Japan lags in ICT investment. Morikawa (2014b) finds that some firms' productivity growth rates in the services sector are not necessarily low. Ito and Lechevalier (2009) focus on the dispersion of productivity growth across heterogeneous firms, finding evidence that internationalization has a significant and positive impact on productivity dispersion. Jorgenson and Timmer (2011) insist that the classical trichotomy of agriculture, manufacturing, and services has lost most of its relevance and emphasize the heterogeneity of different subsectors, especially in services.

also develops a multisectoral analysis to investigate the sources of labor productivity growth dynamics in Japan more in detail. Specifically, we investigate the change in the sources of productivity growth dynamics not only among the agriculture, industry, and services sectors but also within these sectors. Since these sources differ widely by sector, we must explore sectoral performance to precisely assess how and why Japan is suffering from BGD.

Finally, this is the first attempt to deal with the Japanese economy in terms of BGD. In fact, to the best of our knowledge, no study has yet investigated whether the Japanese economy suffers from BGD. Even if Japan has been analyzed in previous studies, it has only been one part of a sample of cross-country data. Hence, the Japanese economy has not been subject to close scrutiny in this regard. We shed light on this issue by using the Japan Industrial Productivity (JIP) database created by the Research Institute of Economy, Trade and Industry (RIETI), which enables us to examine macroeconomic performance in terms of industrial foundation.

For this purpose, this paper presents three analytical devices of decomposition formulas for the aggregate labor productivity growth rate, the fixed share growth rate (FSGR) analysis based on Nordhaus (2008), and the transitional probability matrix framework. These are logically related in the following manner. In the decomposition analysis, the generally exact and additive decomposition (GEAD), the GEAD of Diewert (2015), and CSLS decomposition by the Centre for the Study of Living Standards are employed, which are alternative ways of detecting the symptoms of BGD at *a point in time*. For example, a negative reallocation growth effect in the decomposition analysis can be symptomatic of BGD, as we see below. However, it does not necessarily imply having overall BGD, because BGD is a gradual phenomenon. Therefore, BGD should be examined from a dynamic perspective to allow us to diagnose whether the symptom is *persistent* or *temporal*. In doing so, the FSGR analysis and transitional probability matrix framework play important roles. If BGD is a persistent phenomenon, this is manifested in a lower or falling FSGR in later years. However, since BGD might be curable, the transition probability matrix is useful to estimate whether the patient (e.g. a sector) is still suffering from BGD in the future. Moreover, this matrix is also useful for determining the duration of the disease.

The remainder of this paper is organized as follows. Section 2 explains the database used in this study and defines the sectoral classification. Section 3 is a decomposition analysis of the aggregate labor productivity growth rate. Section 4 complements the decomposition analysis by investigating where, how, and why BGD is undermining the Japanese economy. The conclusions are presented in Section 5. In particular, we show that BGD is silently latent in the Japanese economy. However, the magnitude is miniscule, and it is not a durable phenomenon.

## 2. The JIP Database 2014 and Sectoral Classification

We use the JIP database 2014 compiled by RIETI throughout our empirical analysis. This database consists of various types of annual data for 1970–2011 required to estimate the economic activities of 108 industries in the Japanese

TABLE 1
The Highest-, Middle-, and Lowest-Level Classifications, Based on the JIP Database

| Code in highest-level classification | | Code in middle-level classification | | Original number in JIP (lowest-level classification) |
|---|---|---|---|---|
| L1 | Agriculture | M1 | Agriculture | 1–6 |
| L2 | Industry | M2 | Export core manufacturing | 42–57 |
| | | M3 | Other manufacturing | 8–41, 58–59, 92 |
| | | M4 | Other industries | 7, 60–66 |
| L3 | Service | M5 | Financial services | 69–70 |
| | | M6 | Business-related services | 67, 73–88, 91, 93, 99, 106 |
| | | M7 | Consumer services | 68, 71, 89–90, 94–97 |
| | | M8 | Public services | 80, 82–84, 98, 100–105, 107 |

*Note*: Compiled by the author on the basis of the JIP 2014 database, Franke and Kalmbach (2005), and Uemura and Tahara (2015).

economy. It also forms part of the EU's World Input–Output Database project, successor to the EU KLEMS project. Because investigating the sources of labor productivity growth dynamics requires considering the changes affecting disaggregated units, we need statistical data that can capture multisectoral performance. The JIP database of RIETI is one of the most appropriate databases for this purpose.

This study uses 106 sectors at the lowest-level classification in the JIP database. The housing sector (no. 72) and activities not classified elsewhere (no. 108) are excluded, because some important data such as the number of workers and man–hours are unavailable. We aggregate these 106 lowest-level classifications into three or eight subsectors to consider the sources of productivity growth dynamics. Table 1 summarizes the correspondence among these classifications.

The highest-level classification is based on the standard classification of the agriculture, industry, and services sectors. They are also divided into eight middle-level classifications. The agriculture sector (L1) directly corresponds to the agriculture sector M1; the industry sector (L2) corresponds to M2, M3, and M4; and the services sector (L3) includes M5, M6, M7, and M8. This industrial classification is based on Franke and Kalmbach (2005) and Uemura and Tahara (2015). Uemura and Tahara (2015) classify industries on the basis of Franke and Kalmbach (2005), confirming that the Japanese industrial structure is similar to that of Germany, and that there is a strong industrial linkage between the export core manufacturing and business-related services sectors in both countries. In particular, the export core manufacturing sector plays an important role in leading productivity growth dynamics in both the current study and their studies. This sector is defined as the sectors the export–output ratios of which are constantly over 20 percent from 1980 to 2000. According to the highest-level classification, we pay attention to the economic performance of these three classically defined sectors. In addition, by using the low- and middle-level classifications, we explore heterogeneous performance within the same sector.

The original data source in the JIP database 2014 and construction of the variables to calculate the labor productivity growth rate in this study are explained as follows:

- Nominal value added is taken from the "Growth accounting" table (sheet name NV).
- Real value added is taken from the "Growth accounting" table (sheet name V), evaluated at 2000 prices.
- Man–hours are taken from the "Labor input" table (sheet name 3–8).
- Prices are calculated by dividing nominal value added by real value added.
- Labor productivity is defined as the ratio of real value added to man–hours.

Instead of the TFP growth rate, we use the labor productivity growth rate in this study. First, labor productivity growth is the fundamental determinant of the differences in living standards in the long run. In this sense, it is important to examine labor productivity growth dynamics. Second, although productivity growth can be interpreted as both labor productivity and TFP growth in the Baumol model, labor is only a factor of production in this model. Therefore, it is more natural to consider the growth rate of productivity as that of labor. Finally, the JIP database 2014 has limited information on sectoral TFP growth rates. Although it includes sectoral TFP growth rates in the "Growth accounting" table, because it lacks data on sectoral TFP levels, the data do not fit with the decomposition analysis and the construction of variables at the middle-level sectoral classification.

## 3. Sources of Labor Productivity Growth Dynamics

### 3.1. *Three Formulas Measuring the Sources of Labor Productivity Growth*

This section quantitatively extracts the sources of labor productivity growth and degree of BGD. We use the GEAD presented by Tang and Wang (2004) and Dumagan (2013), the GEAD of Diewert (2015), and the CSLS decomposition (Sharpe, 2010; Sharpe and Thomson, 2010; de Avillez, 2012). As we see below, these methods decompose the aggregate labor productivity growth rate into certain effects in different ways. Table 2 summarizes the abbreviations for these effects.

TABLE 2

A List of Abbreviations in Decomposing Aggregate Labor Productivity (ALP) Growth

| Abbreviation in: | | Formal name |
|---|---|---|
| GEAD | GEAD | Generalized Exactly Additive Decomposition |
| | PPGE | Pure Productivity Growth Effect |
| | DE | Denison Effect |
| | BE | Baumol Effect |
| | AERPC | Aggregate Effect of Relative Price Changes |
| CSLS | CSLS | Centre for the Study of Living Standards |
| | WSE | Within-Sector Effect |
| | RLE | Reallocation Level Effect |
| | RGE | Reallocation Growth Effect |
| Diewert's GEAD | DirE | Direct Effect |
| | OPWE | Output Price Weighting Effect |
| | LIRE | Labor Input Reallocation Effect |

Each formula has both advantages and disadvantages. For example, the advantage of the GEAD is exact for any long period, base-year invariant, and valid for all types of price index numbers. This technique thus enables us to measure pure productivity growth and reallocation effects regardless of the measure of real output (Tang and Wang, 2004; Dumagan, 2013). However, subsequent studies indicate that the labor reallocation effects in the GEAD are affected by the effect of relative price changes (de Avillez, 2012; Diewert, 2015; Reinsdorf, 2015; Dumagan and Balk, 2016). Generally, this is not consistent with the economic definition of productivity growth, which means expanding the production possibility frontier to include changes in output price as a contribution to aggregate labor productivity growth. Instead, the productivity measurement should be conducted based on changes in real terms as much as possible.

Then, we also present the GEAD of Diewert (2015) to isolate the effect of the relative price changes included in the aggregate labor productivity growth rate. In addition, the CSLS decomposition is employed to extract the sources of aggregate labor productivity growth based on changes in the real variables. The GEAD of Diewert (2015) offers a decomposition technique that measures the contribution of relative price changes to the aggregate labor productivity growth rate. The CSLS decomposition differs from the GEAD in that it does not incorporate price effects into the sectoral contribution through the labor reallocation. These formulas can be appropriately employed to detect the sources of productivity growth in the JIP database 2014, because the database measures the real value added by using the constant price index based on the year 2000.[2] Contributions sum exactly to the aggregate labor productivity growth rate under these three formulas if the real output price is measured by the constant price index (Diewert, 2015; Reinsdorf, 2015). As we show below, the sum of the contributions of the GEAD, Diewert's GEAD, and the CSLS is the same, namely equal to the aggregate labor productivity growth rate.

A great deal of space is required to explain the detailed derivation of aggregate labor productivity growth using these techniques. Therefore, this paper leaves the explanation to the original works, and shows the essence of each decomposition.

The following is a list of the main notation and environment used in this paper. Consider an economy with $n$ sectors, where the subscript $i$ indicates a

[2]The constant price index may overestimate (underestimate) the importance of industries with frequent price decreases (increases). Moreover, it also tends to overestimate the real side of the economy, especially when the estimation year differs from the base year. This issue remains in our calculation, as we show below through the aggregate effect of relative price changes (AERPC). The chained index method can minimize these problems by sequentially using the price structure of the previous year in the calculation; however, this method involves the problem of the non-additive issue. As the aggregate is defined by the sum of its components, traditional ways of computing industrial contributions to aggregate labor productivity growth based on the additivity of real output are no longer valid. Further, when one employs the database using a chained index to measure real values, the CSLS decomposition is not exact and additive and the contributions do not match those measured by the constant price index (de Avillez, 2012). The GEAD decomposes aggregate labor productivity growth into industrial contributions to address these problems. However, when the database is based on a constant price index such as the JIP database 2014, given the aggregate labor productivity growth rate and if the assumption of constant labor shares is true, a negative (positive) AERPC in the GEAD implies that the pure productivity growth effect (PPGE) may be overestimated (underestimated).

variable for the $i$th sector. $Y_i$ is the nominal value added, $P_i$ is the price level, $X_i$ is the real value added, which is measured by using deflated nominal output, $L_i$ is the labor input in man–hours, and $q_i = X_i / L_i$ is the labor productivity. The aggregate real value added is $X_t = \sum_i X_{i,t}$ and the aggregate nominal value added is $Y_t = \sum_i Y_{i,t} = \sum_i P_{i,t} X_{i,t}$. Since real value added is measured by using the constant price index in the JIP database 2014, these relationships always hold. The sector's share in aggregate real value added is $x_{i,t} = X_{i,t} / X_t$ and that in aggregate nominal value added is $y_{i,t} = Y_{i,t} / Y_t$. The labor input used in the aggregate economy is $L_t = \sum_i L_{i,t}$. Then, the aggregate labor productivity level is given by $q_t = X_t / L_t$. The relative output price is defined by the ratio between a sector's price level and economy-wide prices, meaning that $p_i = P_i / P$. Finally, each sector's labor input share is $l_i = L_i / L$. The variable $t$ indicates the time period, the hat symbol represents the growth rate of each variable, and $\Delta$ refers to the change in each variable.

In the GEAD, the aggregate labor productivity growth $\hat{q}_t$ in one period from $t-1$ to $t$ can be written as

$$(1) \qquad \hat{q}_t = \underbrace{\sum_i y_{i,t-1} \hat{q}_{i,t}}_{\text{PPGE}} + \underbrace{\sum_i \frac{q_{i,t-1}}{q_{t-1}} \Delta(l_{i,t} p_{i,t})}_{\text{DE}} + \underbrace{\sum_i \frac{q_{i,t-1}}{q_{t-1}} \Delta(l_{i,t} p_{i,t}) \hat{q}_{i,t}}_{\text{BE}} .$$

Equation (1) shows that the aggregate labor productivity growth rate $\hat{q}_t$ can be decomposed into the PPGE, the Denison effect (DE), and the Baumol effect (BE).

In the GEAD of Diewert (2015), the aggregate labor productivity growth $\hat{q}_t$ can be written as

$$(2) \qquad \begin{aligned} \hat{q}_t = & \underbrace{\sum_i y_{i,t-1} \hat{q}_{i,t} \left\{ 1 + \frac{1}{2} \hat{p}_{i,t} + \frac{1}{2} \hat{l}_{i,t} + \frac{1}{3} \hat{l}_{i,t} \hat{p}_{i,t} \right\}}_{\text{DirE}} \\ & + \underbrace{\sum_i y_{i,t-1} \hat{p}_{i,t} \left\{ 1 + \frac{1}{2} \hat{q}_{i,t} + \frac{1}{2} \hat{l}_{i,t} + \frac{1}{3} \hat{l}_{i,t} \hat{q}_{i,t} \right\}}_{\text{OPWE}} \\ & + \underbrace{\sum_i y_{i,t-1} \hat{l}_{i,t} \left\{ 1 + \frac{1}{2} \hat{q}_{i,t} + \frac{1}{2} \hat{p}_{i,t} + \frac{1}{3} \hat{p}_{i,t} \hat{q}_{i,t} \right\}}_{\text{LIRE}} . \end{aligned}$$

Diewert's GEAD decomposes the aggregate labor productivity growth rate $\hat{q}_t$ into the direct effect (DirE), the output price weighting effect (OPWE), and the labor input reallocation effect (LIRE). Since growth rates are generally small, the other interaction terms with symmetric weights take much smaller values. Therefore, although the other terms include effects other than the first term, it is the first term in each effect that is the most dominant. The sectoral labor productivity growth rate, sectoral real output price growth rate, and sectoral labor input share growth rate play an important role in the DirE, OPWE, and LIRE, respectively.

Finally, in the CSLS decomposition, the aggregate labor productivity growth $\hat{q}_t$ can be written as

$$\hat{q}_t = \underbrace{\sum_i x_{i,t-1}\hat{q}_{i,t}}_{\text{WSE}} + \underbrace{\sum_i \left(\frac{q_{i,t-1} - q_{t-1}}{q_{t-1}}\right)\Delta l_{i,t}}_{\text{RLE}} + \underbrace{\sum_i \left(\frac{\Delta q_{i,t-1} - \Delta q_{t-1}}{q_{t-1}}\right)\Delta l_{i,t}}_{\text{RGE}}. \tag{3}$$

Equation (3) shows that the aggregate labor productivity growth rate $\hat{q}_t$ can be decomposed into the within-sector effect (WSE), the reallocation level effect (RLE), and the reallocation growth effect (RGE).

These formulas have both similarities and differences. Although the weights differ, the PPGE, DirE, and WSE capture the sectoral contribution mainly due to sectoral labor productivity improvements. Because these sources principally come from each sector, this study uniquely calls them the within-sector productivity growth effects. The GEAD and CSLS decompositions capture the effects of the labor reallocation with the DE, BE, RLE, and RGE. The DE and RLE measure the reallocation effects based on the difference in productivity level. Even when the sectoral labor productivity growth rate is the same among sectors, the movement of labor employment from a relatively low to a relatively high level sector can raise the aggregate labor productivity growth rate. The BE and RGE measure them by focussing on the change in productivity. Baumol (1967) and Baumol *et al.* (1985) find that sectors with low productivity growth could increase their labor input and thus their relative size, which these effects try to capture. They are negative when non-progressive (progressive) sectors are gaining (losing) relative size over time.

As equation (1) shows, the DE and BE include the change in relative price terms. By contrast, the CSLS, equation (3), extracts the effect of the labor reallocation on the basis of real terms only, which are independent of the change in relative prices. Diewert's GEAD, equation (2), also captures the effect of the labor reallocation (LIRE), while reducing the effect of the change in relative prices. Moreover, it extracts the impact of the change in the industry's real output prices by isolating the OPWE.

### 3.2. *Decomposition Analysis of Labor Productivity Growth*

Table 3 shows the sectoral labor productivity growth rate (A), the decomposition of the aggregate labor productivity growth rate in terms of the contributions of the three effects(B), and the sectoral contribution (C) in the three types of formulas. These formulas give the same sum of contributions, which is equal to the aggregate labor productivity growth rate shown at the bottom.

Part (A) shows that agriculture has sometimes realized the highest productivity growth rate. However, the value added share and man–hours share of this sector are small. Consequently, the contribution of this sector is generally much smaller. Further, the industry sector generally plays the role of the progressive sector compared with the services sector. However, since the value added share and

TABLE 3

THE SECTORAL LABOR PRODUCTIVITY GROWTH RATE AND DECOMPOSITION OF ALP BY THREE FORMULAS (PERCENT)

(A) Labor productivity growth rate

| | 1970–5 | 1975–80 | 1980–5 | 1985–90 | 1990–5 | 1995–2000 | 2000–5 | 2005–10 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 7.660 | 0.141 | 8.221 | 4.247 | −2.490 | 9.555 | 0.853 | 1.893 | 3.760 |
| Industry | 3.040 | 0.994 | 2.503 | 3.821 | 0.337 | 2.159 | 6.550 | 13.366 | 4.096 |
| Service | 2.431 | 2.574 | 2.020 | 2.726 | 1.814 | 1.414 | 2.433 | 0.305 | 1.965 |

(B) As per effect

| | 1970–5 | 1975–80 | 1980–5 | 1985–90 | 1990–5 | 1995–2000 | 2000–5 | 2005–10 | Average |
|---|---|---|---|---|---|---|---|---|---|
| **(B1) GEAD** | | | | | | | | | |
| PPGE | **5.361** | **5.198** | **3.891** | **4.918** | **2.087** | **2.341** | **4.333** | 1.552 | **3.710** |
| DE | 0.015 | −0.360 | −0.053 | −0.217 | −0.140 | 0.055 | 1.131 | **4.603** | 0.629 |
| BE | −1.982 | −2.563 | −1.079 | −1.250 | −0.745 | −0.434 | −1.744 | −1.475 | −1.409 |
| (AERPC) | −2.466 | −3.332 | −2.146 | −1.497 | −0.652 | −0.494 | 0.000 | 3.090 | −0.937 |
| **(B2) Diewert's GEAD** | | | | | | | | | |
| DirE | **4.384** | **3.931** | **3.427** | **4.300** | **1.712** | **2.130** | **3.439** | 0.816 | **3.018** |
| OPWE | −1.537 | −1.947 | −1.302 | −0.984 | −0.390 | −0.241 | 0.649 | **3.857** | −0.237 |
| LIRE | 0.546 | 0.292 | 0.635 | 0.136 | −0.121 | 0.073 | −0.368 | 0.006 | 0.150 |
| **(B3) CSLS** | | | | | | | | | |
| WSE | **2.229** | **1.682** | **2.416** | **3.351** | **1.316** | **1.887** | **4.333** | **4.277** | **2.686** |
| RLE | 1.229 | 0.619 | 0.536 | 0.331 | 0.018 | 0.055 | −0.195 | 0.202 | 0.349 |
| RGE | −0.066 | −0.026 | −0.192 | −0.230 | −0.133 | 0.020 | −0.418 | 0.201 | −0.105 |

(C) As per sector

| | 1970–5 | 1975–80 | 1980–5 | 1985–90 | 1990–5 | 1995–2000 | 2000–5 | 2005–10 | Average |
|---|---|---|---|---|---|---|---|---|---|
| **(C1) GEAD** | | | | | | | | | |
| Agriculture | 0.113 | −0.293 | −0.035 | −0.049 | −0.087 | 0.009 | 0.008 | 0.060 | −0.034 |
| Industry | 0.106 | 0.849 | 1.140 | 1.445 | −0.455 | 0.258 | 0.839 | 1.059 | 0.655 |
| Service | **3.174** | **1.720** | **1.654** | **2.055** | **1.743** | **1.695** | **2.873** | **3.561** | **2.309** |
| **(C2) Diewert's GEAD** | | | | | | | | | |
| Agriculture | 0.113 | −0.293 | −0.035 | −0.049 | −0.087 | 0.009 | 0.008 | 0.060 | −0.034 |
| Industry | 0.106 | 0.849 | 1.140 | 1.445 | −0.455 | 0.258 | 0.839 | 1.059 | 0.655 |
| Service | **3.174** | **1.720** | **1.654** | **2.055** | **1.743** | **1.695** | **2.873** | **3.561** | **2.309** |
| **(C3) CSLS** | | | | | | | | | |
| Agriculture | 0.600 | 0.323 | 0.468 | 0.248 | 0.032 | 0.289 | 0.041 | 0.055 | 0.257 |
| Industry | 1.215 | 0.417 | 0.961 | 1.548 | 0.060 | 0.690 | **1.974** | **4.349** | **1.402** |
| Service | **1.578** | **1.536** | **1.331** | **1.655** | **1.110** | **0.983** | 1.705 | 0.276 | 1.272 |
| **ALP growth rate** | 3.393 | 2.276 | 2.760 | 3.451 | 1.201 | 1.962 | 3.720 | 4.680 | 2.930 |

*Note*: From the author's calculation based on equations (1–3). In parts (B) and (C), the largest contributions in each decomposition are emphasized in bold.

man–hours share change over time and differ between these two sectors, their contributions to the aggregate labor productivity growth rate also change (B, C).

According to part (B), it is common that the within-sector productivity growth effects (PPGE, DirE, and WSE) are positive and are the most important contributions to aggregate labor productivity growth except for 2005–10. In this period, the DE is the most dominant effect in the GEAD (B1) and the OPWE is the most dominant effect in Diewert's GEAD (B2). In terms of the average contribution of every period, within-sector productivity growth still plays the most important role. That is, technological progress at the sector level is an important source of productivity growth dynamics.

In terms of sectoral performance (C), it is generally common that the main source of aggregate labor productivity growth is the contribution by services, followed by the industry sector. Only in the CSLS decomposition for the 2000s is the industry sector's contribution to aggregate labor productivity higher than that for services. The agriculture sector does not make a substantial contribution in any formulas, even though the productivity growth rate itself is high.

As we indicated above, the GEAD cannot sufficiently exclude the effect of relative price changes from the labor reallocation effect. Therefore, the DE and BE in the GEAD may reflect the AERPC. The AERPC, shown in parentheses in part (B1) of Table 3, quantifies this effect, which is extracted from DE and BE in the GEAD. The detail of the calculation is explained in the Appendix (in the online Supporting Information). The AERPC indicates that the effect of relative price changes tends to be larger as one moves away from the JIP 2014 database's base year 2000. Only when real value is measured on the basis of this year is the AERPC zero. In addition, when decomposed by Diewert's GEAD (B2), the OPWE is by no means miniscule. It contributes to the overall labor productivity growth rate negatively before 2000 and positively thereafter.

Compared with the GEAD, the CSLS decomposition is more independent of relative price changes.[3] In the CSLS decomposition (B3), the RLE and RGE are both concerned with the labor reallocation in real terms. The RLE is positive except for 2000–5, but its magnitude is decreasing. The RGE is negative in most periods; even when it is positive, the impact is very small. These effects are much smaller than those of the WSE. However, even if so, the Japanese economy involves BGD because the RGE is almost constantly negative.

The aggregate labor productivity growth rate is determined by the sum of the contributions of the three effects or the contributions of the three sectors, which is shown at the bottom of Table 3. Aggregate labor productivity growth grew by more than 2 percent from 1970 to 1990, but this rate decreased to less than 2 percent during the lost decade. In the first half of the 2000s, aggregate labor productivity growth recovered rapidly. Thus, the aggregate labor productivity growth rate has not been monotonically decreasing in Japan as Baumol (1967) predicts. Rather, it has been cyclical at a positive rate.

### 3.3. *Sources of Productivity Growth Dynamics and BGD*

The CSLS decomposition is the most appropriate for the purpose of the current study for two reasons. First, the JIP 2014 database defines real values at constant 2000 prices, and therefore the contributions by the CSLS formula are additive and sum exactly to the aggregate labor productivity growth rate. Second,

[3]Although we do not report the detail here, we calculated the correlation coefficients between the sectoral contributions of the DE and BE in the GEAD and those of the OPWE in Diewert's GEAD for every period and found them to be positive and significant at the 1 percent level, except for the BE in 1975–80. Thus, it is likely that the DE and BE are affected by the change in relative prices. On the contrary, the same exercise for the RLE and RGE with the OPWE shows that the relationships between the change in relative prices and the RLE and RGE are not deterministic.

the CSLS decomposition detects those contributions by a progressive (non-progressive) sector as industries with an above (below) average productivity growth rate in real terms with the RGE, which therefore adds clarity to detecting BGD.

Table 4 shows the contributions of the CSLS decomposition for the middle-level (A) and highest-level (B) classifications. Tables A.1 and A.2 in the Appendix (in the online Supporting Information) present the details in the same manner for the GEAD and Diewert's GEAD, respectively.

In part (B1) of Table 4, the within-sector productivity growth effect in industry and services contributed the most to the aggregate labor productivity growth rate in this decomposition. In terms of the rate of contribution, the WSE recorded on average a more than 90 percent contribution of the total growth rate. Although we confirmed that the services sector generally contributed to the aggregate labor productivity growth rate more than the industry sector in Table 3, when measured by the WSE in the CSLS decomposition, the industry sector also played a major role. A deeper insight into the sectoral configuration enables us to understand the source of the productivity growth dynamics. According to part (A1) of Table 4, in the industry sector, it is remarkable that export core manufacturing recorded a large contribution to the aggregate labor productivity growth rate, especially after 2000.[4] In the services sector, business-related services have been the main contributing sector to the aggregate labor productivity growth rate.

The RLE is still positive but the magnitude is smaller compared with the WSE. According to part (B2) of Table 4, the magnitude of the RLE was almost decreasing until 2005, implying that gains from the labor shift toward sectors that have above-average labor productivity levels (or the shift from sectors that have below-average labor productivity levels) has been decreasing among the three sectors. Most of the decreasing positive contribution comes from the agriculture sector. Part (A2) states that while the contributions by the RLE in the industry's subsectors were temporally high in 1970–5 and 2005–10, their rates were low for most periods, specifically in the export core and other manufacturing sectors. Consequently, part (B2) shows that the industry sector's RLE as a whole has been

[4]We have macro- and micro-level reasons why this sector realized a high productivity growth rate. At the macroeconomic level, although forced into collapse by the global financial crisis of 2007–8, an export-led growth regime was temporally established in Japan (Boyer *et al*., 2011). As part (A) of Table 2 shows, the industry sector realized 6.550 percent and 13.366 percent of the labor productivity growth rate in 2000–5 and 2005–10, respectively and most came from the export core manufacturing sector. The labor productivity growth rates in this sector were 16.048 percent and 28.427 percent, realized through a large increase in real value added. In fact, real value added increased by 14.975 percent and 27.464 percent, whereas changes in man–hours in this sector were −1.073 percent and −0.963 percent in these periods. The SNA by the Cabinet Office of Japan records annual average export growth during 2000–7 as 7.022 percent at the macroeconomic level. Thus, external demand sustained the large increase in the productivity growth rate in this sector. As for the micro-level reasons, the literature in this field also gives some hints about why export activity is concerned with productivity increases at the micro level. Ito and Lechevalier (2009, 2010) present a persuasive answer to this question. Ito and Lechevalier (2009) empirically reveal that industries with a higher export intensity tend to have a larger dispersion of productivity and a lower median productivity level in Japan. Their results imply that more productive firms can enjoy the benefits from foreign markets, which should drive the least efficient domestic firms out of business, thereby decreasing productivity dispersion. In addition, Ito and Lechevalier (2010) detect the interaction of innovation and export investments, which is a source of permanent differences in performance among firms. This study implies that these interactions define coherent productive models in 1994–2003, and thus established a foundation for the prominent productivity performance in the export core manufacturing sector thereafter in Japan.

TABLE 4
THE CSLS DECOMPOSITION (PERCENTAGE POINT CONTRIBUTIONS)

(A) Middle-level classification

| | 1970–5 | 1975–80 | 1980–5 | 1985–90 | 1990–5 | 1995–2000 | 2000–5 | 2005–10 | Average |
|---|---|---|---|---|---|---|---|---|---|
| **(A1) WSE** | | | | | | | | | |
| Agriculture | 0.237 | −0.021 | 0.215 | 0.116 | −0.053 | 0.161 | **0.026** | 0.018 | 0.087 |
| Export core manufacturing | 0.220 | **0.510** | 0.264 | 0.522 | 0.291 | 0.392 | **1.867** | **3.923** | **0.999** |
| Other manufacturing | **0.564** | 0.044 | **1.013** | 0.403 | 0.280 | 0.232 | 0.341 | 0.099 | 0.372 |
| Other industries | 0.158 | **−0.161** | **−0.047** | **0.747** | **−0.464** | 0.094 | 0.225 | −0.029 | **0.065** |
| Financial services | 0.238 | 0.088 | 0.220 | 0.702 | 0.042 | 0.126 | 0.294 | **−0.300** | 0.176 |
| Business-related services | **0.035** | 0.410 | 0.308 | 0.678 | **1.013** | **0.631** | 1.139 | 0.001 | 0.527 |
| Consumer services | 0.359 | 0.366 | 0.292 | 0.141 | −0.089 | **0.061** | 0.159 | 0.296 | 0.198 |
| Public services | 0.420 | 0.446 | 0.150 | **0.041** | 0.295 | 0.189 | 0.283 | 0.269 | 0.262 |
| **(A2) RLE** | | | | | | | | | |
| Agriculture | **0.532** | **0.408** | **0.367** | **0.212** | **0.088** | **0.191** | 0.031 | 0.065 | **0.237** |
| Export core manufacturing | 0.034 | **−0.012** | **−0.123** | −0.003 | −0.006 | −0.003 | −0.021 | **0.103** | −0.004 |
| Other manufacturing | 0.115 | 0.069 | −0.043 | **−0.123** | 0.019 | 0.010 | −0.010 | 0.063 | 0.013 |
| Other industries | 0.281 | 0.063 | 0.005 | 0.011 | 0.047 | 0.002 | 0.001 | 0.057 | 0.058 |
| Financial services | **0.005** | 0.012 | 0.012 | 0.006 | −0.002 | −0.036 | −0.035 | 0.056 | 0.002 |
| Business-related services | 0.058 | −0.006 | 0.099 | 0.096 | **−0.075** | −0.038 | −0.080 | −0.037 | 0.002 |
| Consumer services | 0.014 | 0.041 | 0.167 | 0.193 | 0.008 | −0.014 | **0.068** | 0.034 | 0.064 |
| Public services | 0.191 | 0.044 | 0.052 | −0.063 | −0.061 | **−0.057** | **−0.149** | **−0.138** | **−0.023** |
| **(A3) RGE** | | | | | | | | | |
| Agriculture | **−0.169** | −0.064 | **−0.115** | −0.080 | −0.004 | **−0.064** | −0.016 | −0.028 | −0.067 |
| Export core manufacturing | −0.040 | **0.057** | **0.023** | 0.008 | **−0.037** | 0.019 | **−0.273** | **0.256** | 0.002 |
| Other manufacturing | −0.149 | **−0.110** | −0.077 | −0.044 | −0.033 | −0.041 | −0.107 | **−0.079** | **−0.080** |
| Other industries | 0.033 | −0.044 | −0.055 | **0.026** | −0.037 | −0.016 | −0.049 | −0.044 | −0.023 |
| Financial services | 0.021 | 0.015 | 0.022 | 0.011 | 0.000 | −0.003 | −0.021 | −0.017 | 0.003 |
| Business-related services | 0.056 | 0.057 | −0.013 | **−0.093** | −0.010 | 0.058 | **0.048** | 0.069 | 0.021 |
| Consumer services | **0.125** | 0.031 | 0.001 | −0.044 | −0.019 | 0.006 | −0.047 | −0.010 | 0.005 |
| Public services | 0.057 | 0.032 | 0.021 | −0.013 | **0.008** | **0.060** | 0.046 | 0.054 | **0.033** |

(B) Highest-level classification

| | 1970–5 | 1975–80 | 1980–5 | 1985–90 | 1990–5 | 1995–2000 | 2000–5 | 2005–10 | Average |
|---|---|---|---|---|---|---|---|---|---|
| **(B1) WSE** | | | | | | | | | |
| Agriculture | 0.237 | −0.021 | 0.215 | 0.116 | −0.053 | 0.161 | 0.026 | 0.018 | 0.087 |
| Industry | 0.942 | 0.393 | **1.230** | **1.672** | 0.107 | 0.719 | **2.432** | **3.994** | **1.436** |
| Service | **1.051** | **1.311** | 0.971 | 1.562 | **1.262** | **1.007** | 1.875 | 0.266 | 1.163 |
| Total | 2.229 | 1.682 | 2.416 | 3.351 | 1.316 | 1.887 | 4.333 | 4.277 | 2.686 |
| **(B2) RLE** | | | | | | | | | |
| Agriculture | **0.532** | **0.408** | **0.367** | 0.212 | **0.088** | **0.191** | **0.031** | 0.065 | **0.237** |
| Industry | 0.430 | 0.120 | −0.160 | −0.115 | 0.061 | 0.009 | −0.030 | **0.223** | 0.067 |
| Service | 0.268 | 0.091 | 0.329 | **0.233** | −0.130 | −0.145 | −0.196 | −0.086 | 0.045 |
| Total | 1.229 | 0.619 | 0.536 | 0.331 | 0.018 | 0.055 | −0.195 | 0.202 | 0.349 |
| **(B3) RGE** | | | | | | | | | |
| Agriculture | −0.169 | −0.064 | −0.115 | −0.080 | **-0.004** | −0.064 | −0.016 | −0.028 | −0.067 |
| Industry | −0.156 | −0.096 | −0.109 | **-0.010** | −0.107 | −0.038 | −0.429 | **0.132** | −0.102 |
| Service | **0.259** | **0.134** | **0.031** | −0.140 | −0.022 | **0.122** | **0.027** | 0.096 | **0.063** |
| Total | −0.066 | −0.026 | −0.192 | −0.230 | −0.133 | 0.020 | −0.418 | 0.201 | −0.105 |

*Note*: From the author's calculation based on equation (3). In part (A), the largest and smallest contributions in each decomposition are emphasized in bold. In part (B), the largest contribution in each decomposition is emphasized in bold.

mostly stagnating. The RLE in the services sector in the past 20 years has been negative. On average, the consumer services sector has recorded the highest contribution, while the public services sector has made the lowest contribution. In any case, the magnitudes of the RLE in all subsectors and all periods have been small.

According to part (B3) of Table 4, the sign of the RGE turns negative and the magnitude is generally much smaller than those of the WSE and RLE. The negative or stagnant performance of the RGE implies that the labor input share is decreasing (increasing) in a sector in which the growth rate of labor productivity is above (below) average. The negative values can be prominently found in the agriculture and industry sectors. The industry sector's RGE performance is generally negative. To be more precise, in (A3), other manufacturing and industries' contributions have been almost constantly negative. Export core manufacturing's RGE changes cyclically, and the magnitude is miniscule. In the services sector, the financial and consumer services sectors show a rather decreasing trend, whereas the business-related and public services sectors have recently present better performance on average. Nonetheless, these contributions are small.

In sum, the sources of productivity growth dynamics principally come from the within-sector productivity growth effect. The contribution of the RLE comes second and that of the RGE is last. Both the reallocation level and growth effects (RLE and RGE) made miniscule contributions to aggregate labor productivity growth. The RGE was negative, led by the agriculture and industry sectors, and thus BGD is arising in these sectors. However, the largest negative contribution was only −0.418 percent in 2000–5, which is only −11.242 percent in terms of the rate of contribution to the overall growth rate.[5] Therefore, even if BGD resides in the Japanese economy, it is not so serious as to negatively determine the aggregate labor productivity growth rate. BGD is sufficiently covered by the within-sector productivity growth effect.

## 4. A Further Investigation into BGD

This section complements the results presented in the previous section. We explore in which sector BGD is arising through industrial structural change. We then detect how BGD is arising in Japan in 1970–2010 based on the relative productivity growth rate and the change in the nominal value added share and the man–hours share. We also explain why the magnitude of BGD is miniscule. On this basis, we assess the nature of BGD in Japan.

### 4.1. *FSGR Analysis*

To confirm which sectors of the Japanese economy have gradually been suffering from BGD, we examine aggregate labor productivity on the basis of the analytics of Nordhaus (2008). The method of examining BGD developed by

[5]Sharpe (2010) offers a similar analysis to the current study, and therefore may be used as a benchmark for comparison purposes. According to Table 1 in Sharpe (2010), based on the CSLS decomposition, the RGE has always been negative and it ranges from −0.40 (–19.76) to −0.09 (–7.12) in Canada, whereas it ranges from −0.418 (–11,242) to 0.020 (1.040) in our estimation for Japan (rate of contribution in parentheses). Although the minimum value is lower in Japan, the negative magnitude is generally more severe in Canada than in Japan.

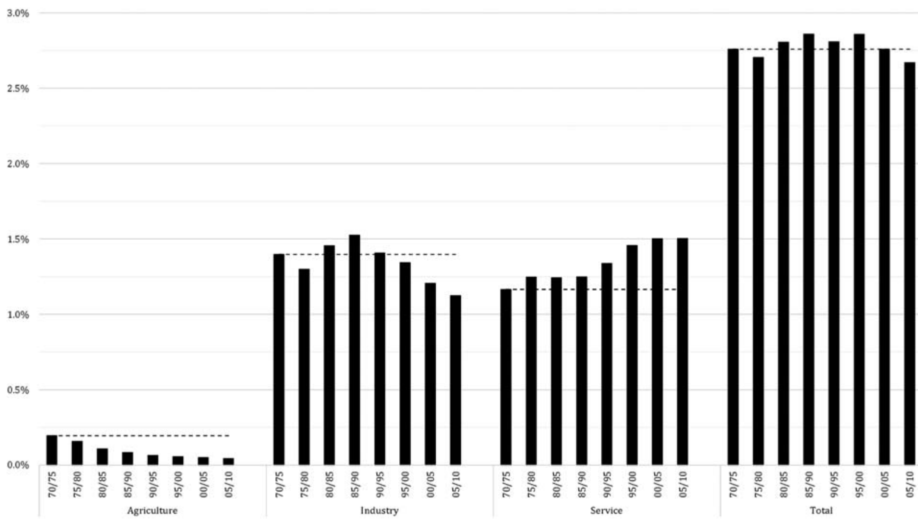


Figure 1. The FSGR of Labor Productivity for the Different Base Years (Middle Level and Total)

*Note*: The dotted line over each sector indicates the FSGR based on the 1970–5 weight.

Nordhaus (2008) is based on the diagnosis that if non-progressive sectors have rising nominal output shares over time, then the aggregate growth rate will reduce as the share of output moves toward non-progressive sectors. The FSGR is

$$\text{FSGR}_T = \sum_{i=1}^{n} y_{i,T}\hat{q}_{i,t}, \tag{4}$$

meaning that it is derived from the sum of sectoral productivity growth weighted by the nominal value added share. By comparing the FSGR for different base years ($T$), we can assess the impact of structural change on labor productivity growth. If the FSGR is lower for later $T$, then the Baumol growth effect is negative, indicating that the shares are moving toward non-progressive sectors. By contrast, if the FSGR is higher for later $T$, then the Baumol growth effect is positive, indicating that the shares are moving toward progressive sectors.

Figure 1 shows the FSGR based on the annual average growth rate of labor productivity $\hat{q}_{i,t}$ between 1970 and 2010, by dividing the contribution of agriculture, industry, and services. The total is the sum of these three sectors.[6] The weights $y_{i,T}$ are the 5-year average nominal value added share after 1970–5. For reference, the dotted line over each sector indicates the FSGR based on the 1970–5 weight.

First, the Baumol growth effect works negatively and monotonically for the agriculture sector in all periods at a low rate. Second, this effect for the industry sector is also depressing on the basis of the post-1985–90 weights. That is, higher (lower) productivity growth sectors in the industry sector have been losing (gaining) their nominal value added share over time, especially since the mid-1980s. Third, the FSGR for services is not monotonically decreasing for all weights, and

[6]We also conducted the same exercise in detail by considering the annual average growth rate of labor productivity of 1970–5, 1980–5, 1990–5, and 2000–5, and the results were the same.

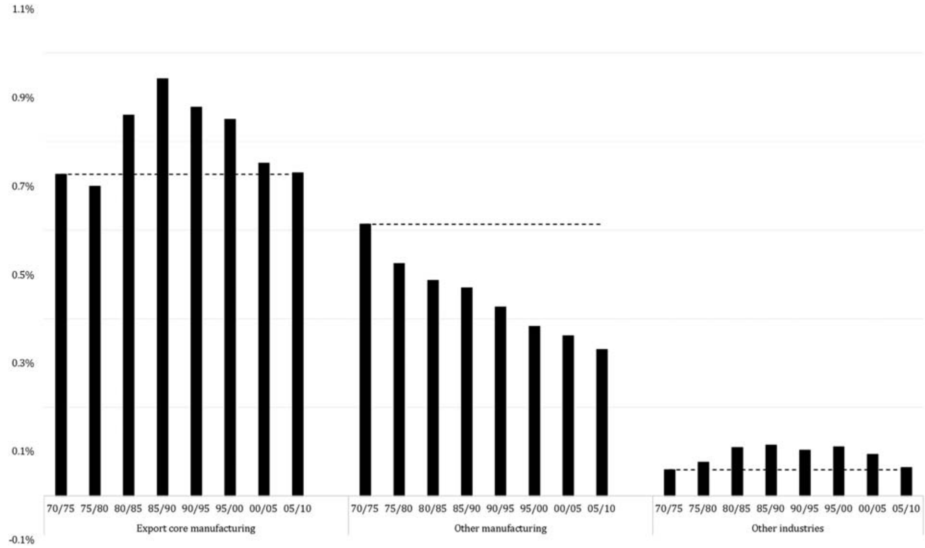


Figure 2. The FSGR of Labor Productivity for the Different Base Years (Industry Sectors)

*Note*: The dotted line over each sector indicates the FSGR based on the 1970–5 weight.

thus this sector is not clearly affected by a negative Baumol growth effect. Rather, the FSGR in the services sector is increasing over time. At the aggregate level, a negative Baumol growth effect is not sufficiently clear to largely reduce the aggregate labor productivity growth rate. The negative Baumol growth effect in the agriculture and industry sectors is countervailed by the positive contribution of the services sector. The countervailing role of structural change in services is one reason why BGD in the Japanese economy has been weak.[7]

To investigate the sectoral sources of the negative and positive Baumol growth effects in more detail, Figures 2 and 3 show the evolution of the FSGR for industry and services, respectively, at the middle-level classification. The subsectors within industry and services show diverse configurations. Figure 2 clearly shows that other manufacturing has been losing its contribution when using the weights of all periods, while export core manufacturing has been losing it when using the weights after 1985–90. Although the FSGR of other industries does not show a clear decreasing trend, the rate is by nature small. In addition, the FSGR based on the 1970–5 and 2005–10 weights is almost the same, meaning that long-run growth in this subsector has not benefitted from structural change. Thus, a negative Baumol growth effect is prominent in export core manufacturing after the mid-1980s and other manufacturing, which explains why the overall contribution from industry has been decreasing.

[7]The decline in the FSGR in Japan is smaller than that in the United States (U.S.). Although this is not the labor productivity growth rate but the TFP growth rate, Nordhaus (2008) finds that the negative Baumol effect decreased the TFP growth rate in the U.S. by 0.64 between 1948 and 2001. However, in the case of Japanese labor productivity, the impact is much smaller than that of the U.S. during 1970–2010, at only 0.089. In fact, Nordhaus (2008) also presents the decline in the FSGR in Figure 7 in four short periods in 1970–2001. Even roughly measuring the loss in those periods from his figure, it ranges from 0.5 percent to no more than 1.0 percent.

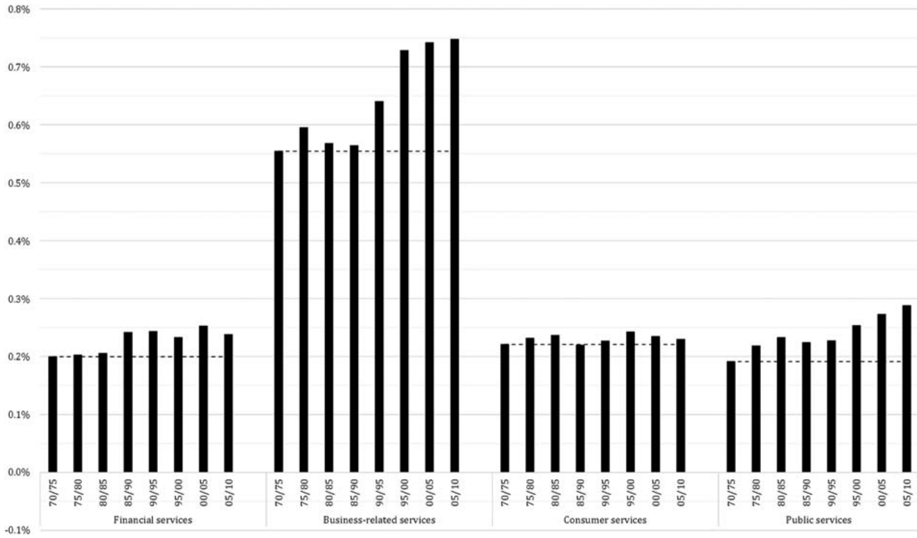


Figure 3. The FSGR of Labor Productivity for the Different Base Years (Services Sectors)
*Note*: The dotted line over each sector indicates the FSGR based on the 1970–5 weight.

Figure 3 shows the evolution of the FSGR for services at the middle-level classification. The business-related services sector has the most important contribution in all periods. This sector's contribution is increasing with later *T*, especially after the mid-1980s. The contribution of public services is increasing slightly over time. With regard to consumer services and financial services, it is difficult to detect a clear trend. In the services sector, the positive Baumol growth effect is working in certain sectors, such as business-related services and public services, whereas the other contributions of the two sectors are not large. Thus, the Baumol growth effect is not working uniquely in the services sector. This means that the productivity growth rate is high in certain services sectors and that the dispersion of the productivity growth rate exists among the services sectors.[8]

[8]Some of the possible indications of the high productivity growth rate of certain services sectors can be presented from representative empirical and theoretical studies that attempt to go beyond the simple model of Baumol (1967). From a theoretical perspective, first, this may be because of endogenous growth in that sector by way of human capital accumulation, innovation, and learning-by-doing (Pugno, 2006; De Vincenti, 2007). By way of a Japanese example, Morikawa (2014a,2016) shows that services firms have fewer product innovations than do manufacturing firms, while in Japan, firms in the services sector conducting innovation activities record much higher productivity than those not conducting them. The second indication is derived from the theoretical explanation by Oulton (2001) and Sasaki (2015) that the high growth rate at the aggregate level can be realized because of the role of services as an intermediate input into industry and final consumption. These roles have productivity growth-enhancing effects, as well as preventing the aggregate labor productivity growth rate from monotonically decreasing. Although there is no solid empirical evidence for Japan thus far, Baumol (2001) recognizes the significant role of services as an intermediate input for the U.S. economy. He indicates that a substantial shift in the labor force has been to intermediate goods, while much of the growth in input use has occurred in the business services and other intermediate goods sectors of the U.S. economy. The contribution of these studies may also suggest why the growth rate is not necessarily monotonically declining in Japan.

In sum, the negative Baumol growth effect in the FSGR sense is not necessarily apparent in the services sector. However, although small, the Baumol growth effect is negative in the agriculture and industry sectors, which is consistent with the results from the RGE in the CSLS decomposition. Thus, led by these sectors, BGD silently undermines labor productivity dynamics.

### 4.2. *The Pattern and Durability of BGD*

This section explores how BGD is dynamically arising and why the impact is small in Japan by classifying types of BGD. In doing so, the labor productivity growth rate in each sector is compared with the aggregate labor productivity growth rate in each period. The progressive (non-progressive) sector is classified as the sector that realized a higher (lower) labor productivity growth rate than the aggregate labor productivity growth rate. Then, BGD undermines the economy owing to the structural change: progressive sectors gradually lose both the labor input share and the nominal value added share, whereas non-progressive sectors gradually gain them. Let us define the former process as type 1 BGD and the latter as type 2 BGD.

We aim to capture the dominant pattern that characterizes how BGD arises in each of the eight sectors by calculating the relative frequency of each type as follows. A subsector included in each middle-level classification (i.e. the sector at the lowest level) suffers from either type 1 or type 2 BGD in a period, but not both. For instance, even if a subsector in agriculture (e.g. rice, wheat production: JIP code no. 1) suffers from type 1 in a period, it may suffer from type 2 in other periods, or may recover from BGD altogether. Figures 4 and 5 show how often the subsectors in each middle-level sector suffered from either type when they fell into BGD in 1970–2010.

Both figures show a similar configuration about the causes of BGD. In the industry sector, BGD is arising mainly because the progressive sector is losing weight in terms of the nominal value added and man–hours shares (type 1 BGD). By contrast, the main cause of BGD in the services sector is that the non-progressive sector is gaining weight in terms of the nominal value added and man–hours shares. Except for financial services, the services sector is dominated by type 2 BGD. These configurations are also observed at the highest-level classification, which is not reported in the figures. For example, in terms of the nominal value added share, type 1 BGD is realized by 35.04 percent in the industry sector but only by 13.14 percent in services, whereas type 2 BGD is realized by 45.19 percent in the services sector but only by 15.16 percent in industry. The agriculture sector shows a configuration similar to that of the industry sector. Thus, when BGD arises, while the industry and agriculture sectors develop type 1, the services sector develops type 2.

Second, a canonical Baumol model predicts structural change: progressive sectors are gradually losing nominal value added and labor input shares (type 1 BGD), whereas non-progressive sectors are gradually gaining these shares over time (type 2 BGD). Since Baumol (1967) explains BGD as a gradual and asymptotic phenomenon, if Baumol's prediction is true, then a sector exhibiting BGD should continue to show this disease. Then, we aim to understand whether such

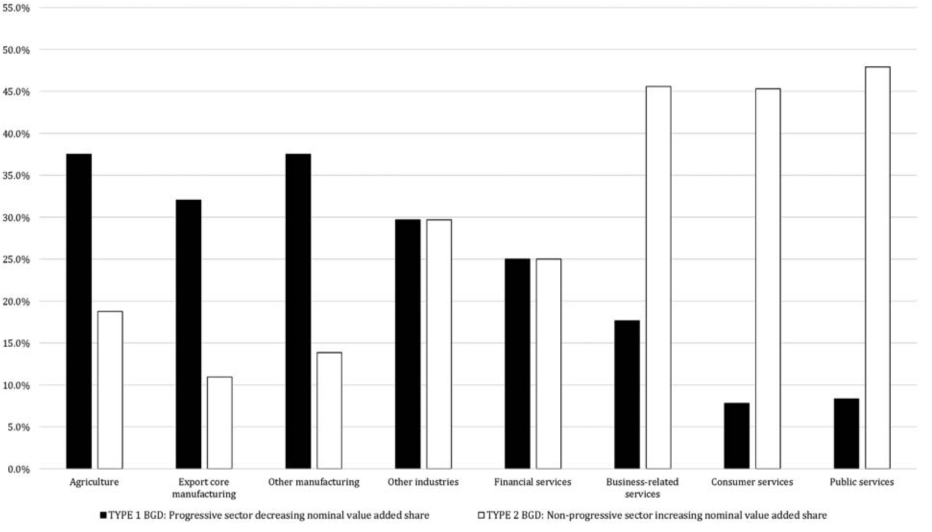


Figure 4. The Relative Frequency that Subsectors in the Middle-Level Classification Caused BGD (Nominal Value Added Share)

*Note*: From the author's calculation based on the JIP database 2014. To calculate the relative frequency for each sector, the denominator is the product of the number of subsectors in the lowest-level classification and that of periods (eight periods during 1970–2010) and the numerator is the number of subsectors in the lowest-level classification that realized type 1 BGD during this period. For example, six subsectors in agriculture recorded type 1 BGD 18 times in total. Hence, the relative frequency of type 1 BGD in agriculture is $(18/(8\times6))\times100=37.5$.

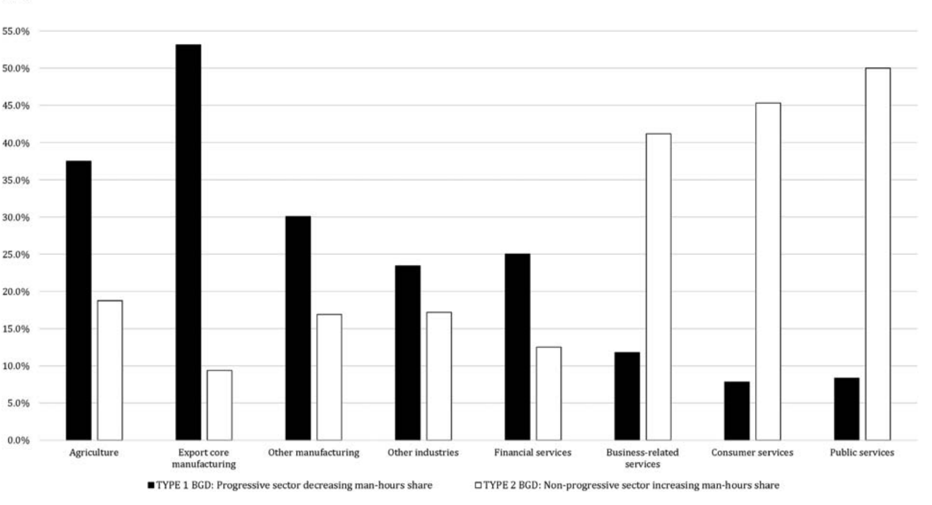


Figure 5. The Relative Frequency that Each Sector Caused BGD in Terms of the Man–Hours Share

*Note*: From the author's calculation based on the JIP database 2014.

structural dynamics are dominant. By dividing into the BGD and non-BGD types and shedding light on the dominant channel of switching or remaining in the same position over time, we can grasp the dynamic nature of BGD in order to understand why the magnitude of BGD is dynamically small in Japan. Motivated by this, we can then calculate the transitional probability matrix over the past 40 years to examine the evolution and duration of BGD.[9]

Table 5 shows the results for 1970–2010 by type of BGD and sector for the nominal value added share (A) and the man–hours share (B). Each row indicates the results according to sector, where (4) "Total (sector)" aggregates all three sectors. Each column indicates the results by type of BGD, where "Total (type)" is the aggregate of both types. The structural change and BGD in the Japanese economy has the following properties.

First, non-BGD is more dominant than BGD, and the duration of non-BGD is more substantial than that of BGD, at both the sectoral and the aggregate levels. As the number of observations shows, the case of initially non-BGD sectors can be observed the most. In addition, the probability that initially BGD sectors remain in the same position is, in general, lower than the probability that initially non-BGD sectors remain in the same position. This finding is clearly confirmed by comparing the top left and bottom right cells in each block: the former is lower than the latter. Non-BGD thus has a sustainable nature, as it is more likely to remain non-BGD than to fall into BGD. This configuration is common regardless of the nominal value added share and labor input shares (part (B)).

Second, in Baumol's model, the duration of BGD should be substantial; however, in the reality of the Japanese economy, duration is relatively weak. Even if a sector initially falls into BGD, it is more likely to escape from there to non-BGD in the next period. This finding is confirmed by comparing the top left and top right cells: the latter is generally higher than the former. Thus, in contrast to Baumol's prediction, BGD is not a dynamically durable phenomenon in Japan. This configuration is almost common among all blocks, except for type 2 BGD in agriculture.

Third, the dynamic pattern of how BGD continues differs by sector. Let us compare the top left cells for types 1 and 2. According to part (B) for industry, for example, type 1 BGD continues with a probability of 43.90 percent, but type 2 BGD continues with a probability of 29.51 percent. On the contrary, in services, type 2 BGD continues with a probability of 48.65 percent, but type 1 BGD continues with a probability of 23.33 percent. In the industry sector, the cause of BGD is that the progressive sector is decreasing the nominal value added and labor input shares, while the non-progressive sector is increasing these shares. By contrast, in the services sector, BGD continues because the non-progressive sector is increasing the nominal value added and labor input shares, whereas the progressive sector is decreasing these shares.

The pattern of how non-BGD continues also differs by sector. In the industry sector, non-BGD continues because the non-progressive sector is decreasing the

[9]Let us remark again that a sector may switch between BGD and non-BGD depending on its performance over time. As we mentioned above, BGD arises because a progressive sector (i.e. a sector with an above-aggregate productivity growth rate) loses weight (type 1 BGD) or a non-progressive sector gains weight (type 2 BGD). If neither of the above holds, the sector is non-BGD.

TABLE 5

The Transitional Probability Matrix

(A) Nominal value added share

| Type 1 | | | | | Type 2 | | | | Total (type) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(1) Agriculture** | | | $t+1$ | | | | $t+1$ | | | | $t+1$ | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 29.41% | 70.59% | 17 | BGD | 71.43% | 28.57% | 7 | BGD | 41.67% | 58.33% | 24 |
| | Non-BGD | 44.00% | 56.00% | 25 | Non-BGD | 8.57% | 91.43% | 35 | Non-BGD | 23.33% | 76.67% | 60 |
| **(2) Industry** | | | $t+1$ | | | | $t+1$ | | | | $t+1$ | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 42.33% | 57.67% | 163 | BGD | 27.87% | 72.13% | 61 | BGD | 38.39% | 61.61% | 224 |
| | Non-BGD | 30.30% | 69.70% | 264 | Non-BGD | 13.11% | 86.89% | 366 | Non-BGD | 20.32% | 79.68% | 630 |
| **(3) Service** | | | $t+1$ | | | | $t+1$ | | | | $t+1$ | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 37.50% | 62.50% | 40 | BGD | 47.50% | 52.50% | 120 | BGD | 45.00% | 55.00% | 160 |
| | Non-BGD | 10.30% | 89.70% | 233 | Non-BGD | 41.18% | 58.82% | 153 | Non-BGD | 22.54% | 77.46% | 386 |
| **(4) Total (sector)** | | | $t+1$ | | | | $t+1$ | | | | $t+1$ | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 40.45% | 59.55% | 220 | BGD | 42.02% | 57.98% | 188 | BGD | 41.18% | 58.82% | 408 |
| | Non-BGD | 22.03% | 77.97% | 522 | Non-BGD | 20.58% | 79.42% | 554 | Non-BGD | 21.28% | 78.72% | 1076 |

(B) Man–hours share

| Type 1 | | | | | Type 2 | | | | Total (type) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(1) Agriculture** | | $t+1$ | | | | $t+1$ | | | | $t+1$ | | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 29.41% | 70.59% | 17 | BGD | 71.43% | 28.57% | 7 | BGD | 41.67% | 58.33% | 24 |
| | Non-BGD | 44.00% | 56.00% | 25 | Non-BGD | 8.57% | 91.43% | 35 | Non-BGD | 23.33% | 76.67% | 60 |
| **(2) Industry** | | $t+1$ | | | | $t+1$ | | | | $t+1$ | | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 43.90% | 56.10% | 164 | BGD | 29.51% | 70.49% | 61 | BGD | 40.00% | 60.00% | 225 |
| | Non-BGD | 30.04% | 69.96% | 263 | Non-BGD | 12.84% | 87.16% | 366 | Non-BGD | 20.03% | 79.97% | 629 |
| **(3) Service** | | $t+1$ | | | | $t+1$ | | | | $t+1$ | | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 23.33% | 76.67% | 30 | BGD | 48.65% | 51.35% | 111 | BGD | 43.26% | 56.74% | 141 |
| | Non-BGD | 9.88% | 90.12% | 243 | Non-BGD | 37.04% | 62.96% | 162 | Non-BGD | 20.74% | 79.26% | 405 |
| **(4) Total (sector)** | | $t+1$ | | | | $t+1$ | | | | $t+1$ | | |
| | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. | | BGD | Non-BGD | Obs. |
| $t$ | BGD | 39.81% | 60.19% | 211 | BGD | 43.02% | 56.98% | 179 | BGD | 41.28% | 58.72% | 390 |
| | Non-BGD | 21.47% | 78.53% | 531 | Non-BGD | 19.54% | 80.46% | 563 | Non-BGD | 20.48% | 79.52% | 1094 |

*Note*: From the author's calculation. Obs. refers to the number of observations. The whole sample in each sector is the sumproduct of the number of subsectors in each category and the seven periods examined. For example, there are six subsectors in agriculture and the duration is measured for the seven periods between 1970–5 and 2005–10. Therefore, the total Obs. in this sector is 42.

nominal value added and labor input shares (e.g. 86.89 percent in part (A)), whereas the progressive sector is increasing these shares (e.g. 69.70 percent in part (A)). By contrast, in the services sector, non-BGD continues because the progressive sector is increasing the nominal value added and labor input shares (e.g. 89.70 percent in part (A)), whereas the non-progressive sector is decreasing these shares (e.g. 58.82 percent in part (A)). This evidence is verified by comparing the bottom right cells for types 1 and 2 for the different sectors; it can also be confirmed by both the nominal value added and the man–hours shares. Finally, the agriculture sector shows a similar pattern to the services sector with regard to these configurations.

We have thus verified that the dominant pattern of BGD in Japan is that the progressive sector in industry is losing weight and the non-progressive sector in services is gaining weight. However, BGD is not a dynamically dominant phenomenon, meaning that even when a sector presents BGD, it is not durable. Non-BGD dynamics are also important in reality. The transitional probability matrix implies that non-BGD dynamics sufficiently countervail BGD dynamics, which also explains why the magnitude of BGD is much smaller in Japan.

## 5. Conclusions

This study has examined the sources of labor productivity growth dynamics in the Japanese economy and investigated the implications of growth disease due to Baumol (1967). We conclude that BGD silently undermines Japanese economic growth. However, the magnitude is much smaller and it is not a durable phenomenon. The main reasons can be presented by summarizing the discussion in each section.

By decomposing aggregate labor productivity dynamics into three effects, we found that the within-sector effects typically lead to a change in aggregate labor productivity growth in any decomposition formula. This effect is mostly positive and it determines the aggregate labor productivity growth rate. It does not decline monotonically but, rather, it is cyclical at a positive rate over time.

In the three decomposition formulas, mainly by using the CSLS decomposition, which is independent of changes in relative prices, to measure the reallocation effects, we detected a negative RGE for most periods. In this sense, the Japanese economy is suffering from BGD; however, the magnitude is generally much smaller than that of the other effects. In terms of sectors, a negative RGE can be observed in the agriculture and industry sectors. In the services sector, a positive RGE is working in certain sectors, such as business-related services and public services.

We then conducted the analysis by using the FSGR to detect in which sector BGD has been arising over the past 40 years. The FSGR also indicates that structural change has arisen in the manner that the Baumol growth effect for the agriculture and industry sectors is negative, whereas this effect is partially positive in the services sector. In industry, other manufacturing and export core manufacturing have been losing their contribution. On the contrary, the positive Baumol growth effect is working in certain services sectors, such as business-related services and public services.

We have also verified that the dominant pattern of BGD differs by sector. If the agriculture and industry sectors suffer from BGD, it is mainly because the progressive sector in industry is losing weight (type 1 BGD). By contrast, if the services sector suffers from BGD, it is mainly because the non-progressive sector is gaining weight (type 2 BGD).

Finally, the transitional probability matrix showed that BGD is not a dynamically durable or dominant phenomenon. Rather, the non-BGD case is also important in Japan. Even when a sector is presented as a symptom of BGD in a period, it is more likely that the sector will recover from BGD than continue to suffer from this in the next period. Therefore, although it exists in the Japanese economy, BGD is much weaker.

We have focused on the Baumol (1967) model to investigate the sources of labor productivity growth dynamics and presented original evidence from the Japanese economy. The model has been extended to many fields such as the role of services as an input, endogenous technological progress, and so on. These extensions generally show that the aggregate growth rate does not decline as Baumol's original model says, which may also suggest the miniscule impact of BGD in Japan. This study does not take these extensions into consideration in a sufficient manner. Therefore, they remain issues for future research.

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## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix
AERPC in GEAD
GEAD and Diewert's GEAD at the Middle-Level Classification
**Table A.1**: GEAD (Percentage Point Contributions)
**Table A.2**: Diewert's GEAD (Percentage Point Contributions)