Wagner's law versus displacement effect

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Abstract

The public sector has grown dramatically over the past few centuries in many developed countries. In this paper, we use wavelet methods to distinguish between two leading explanations for this growth—Wagner's law and the displacement effect. In doing so, we use the long-term data of ten OECD countries for a maximum time span of 1800–2009. We find that the validity of Wagner's law is likely to vary strongly over time for each country. A roughly similar feature in most of the countries is that the law is less valid in the earliest stage of economic development as well as in the advanced stages, with the validity tending to follow an inverted U-shaped pattern with economic development. Further, our results indicate that the long-run growth of government size cannot be adequately explained by Wagner's law. On the other hand, the displacement effect appears to account for the bulk of the growth in most of the countries.

JEL classifications: E62; H50; N40

Keywords: Size of public sector; Wagner's law; Economic development; Displacement effect; Wavelet

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1 Introduction

It is widely accepted that the public sector has grown dramatically over the past few centuries in many developed countries. Multiple theories of government size in the long run have been propounded to explain this.

One of the leading hypotheses is the so-called Wagner's law of increasing state activity, the oldest hypothesis in the literature.[1] The law has been tested for numerous countries and time spans.[2] However, empirical evidence of the law is mixed across countries and periods and we are yet to systematically understand the law. One probable reason for these inconsistent results is that earlier studies gave scant attention to structural changes. In fact, only a handful of recent studies such as Durevall and Henrekson (2011) and Kuckuck (2014) emphasize that the validity of the law evolves over time.

Durevall and Henrekson (2011) analyze long historical data since the early 19th century for Sweden and the United Kingdom and point out that Wagner's law can be confirmed in both countries only during the middle of the long sample period (from roughly 1860 to the mid-1970s). In other words, they find no evidence of the law before 1860 and after the mid-1970s. Their findings suggest that the validity of the law follows an inverted U-shaped pattern over time. Subsequently, Kuckuck (2014) also uses historical data from the mid-19th century for five western European countries (the United Kingdom, Denmark, Sweden, Finland, and Italy) and finds that the law does not hold in advanced economies but does hold in developing economies. Besides supporting the findings of Durevall and Henrekson (2011), Kuckuck (2014) highlights the relevance of each country's stage of economic development.

Similar results are presented by Lamartina and Zaghini (2011), who use a panel data of 23 OECD countries for the period 1970–2006 and find that Wagner's law is more valid when the GDP per capita is low than when it is sufficiently high. More importantly, the authors identify a remarkable decline in long-run elasticity between GDP and public spending in a short period from 1990 to 2006. Thus, although

[1]For example, trade openness, country size, ethnic fragmentation, and income inequality are the other leading factors or determinants of government size. See, for example, Meltzer and Richard (1981), North and Wallis (1982), and Shelton (2007) for a detailed survey of the other leading hypotheses.

[2]The law was initially tested by Lall (1969) and then analyzed by Mann (1980), Singh and Sahni (1984), and Abizadeh and Gray (1985). See, for example, Thornton (1999) for results of Europe, Iyare and Lorde (2004) for Caribbean countries, and Akitoby et al. (2006) for the developing countries. Chow et al. (2002) suggest that controlling for the effects of money supply is crucial for the validity of Wagner's law. Brückner et al. (2012) use oil price shocks as an instrument variable and estimate the permanent income elasticity of government expenditure. While most earlier studies use national-level data, an exception is Narayan et al. (2012), who investigate the law for Indian states.

Durevall and Henrekson (2011) demonstrate at most only two structural breaks during the centuries studied, the potential for more local changes does exist over several decades. In summary, these recent studies seem to provide some systematic evidence, but the continuing challenge for the literature is to identify when the law is operational.

Another leading hypothesis of long-run growth of government size is the displacement effect proposed by Peacock and Wiseman (1961), who examine the long-run government expenditure in the United Kingdom. According to them, taxation is stable in normal periods, but the burden of taxation increases in order to finance government expenditure in times of crisis, for example, during wars, and the higher budgetary levels continue even after the crisis. Thus, the sudden increase in government expenditure in a crisis does not return to the level prior to the crisis, and the government size tends to exhibit stepwise increases through crises, as depicted in Figure 1.[3]

In this paper, we distinguish between Wagner's law and the displacement effect and provide new insight into the existing literature. To better understand the findings of Durevall and Henrekson (2011) and Kuckuck (2014), we also use the long-term data of ten OECD countries for a maximum time span of 1800–2009. This study differs from all previous studies in the following two respects.

First, this is the first study to compare the above two hypotheses. While previous studies have tested each hypothesis separately, they did not try to examine which hypothesis is more supported, but our primary objective is to determine which hypothesis seems more plausible. Second, to accomplish this goal, we utilize wavelet methods.[4] As detailed in Section 3, this method is useful to decompose variables by frequency and can extract the long-run information commonly considered relevant to both Wagner's law and the displacement effect. In addition, wavelet analysis allows for the identification of possible breaks around each time and frequency. Especially, this study is based on historical data and the sample covers periods of large social disturbances, for example, World War I, World War II, and the Great Depression. For an appraisal of the displacement effect and Wagner's law, we need

[3]Compared with the Wagner's law literature, few studies, for example, Goff (1998) and Legrenzi (2004), test the displacement effect.

[4]To test the law, Lamartina and Zaghini (2011), Durevall and Henrekson (2011), Kuckuck (2014), and many others adopt some cointegration analysis methods. Formal structural break tests using the cointegration approach require a certain sample size and might overlook minute breaks that occur frequently. On the other hand, our wavelet approach allows for a local time-varying relationship between government size and economic development and can detect breaks even if they repeat frequently. Kuckuck (2014) examines the structural changes of the law for previously divided subsample periods with each country's stage of economic development, but we try to endogenously detect structural changes if any.

to eliminate their effect on government expenditure in the short to medium term. Although these disturbances are considered hard to handle in previous econometric techniques, given that their effects are relatively transient, we can exclude them by using the wavelet method.

Our main findings are summarized as follows. First, the displacement effect of Peacock and Wiseman (1961) seems to have an important role in explaining a large part of the growth of the public sector in most of the countries. Second, the validity of Wagner's law tends to follow an inverted U-shaped pattern with economic development. This is consistent with Durevall and Henrekson (2011) for Sweden and the United Kingdom and is new evidence for the other countries. That is, our analysis supports the view that Wagner's law is less validated in advanced economic stages, as suggested by Lamartina and Zaghini (2011) and Kuckuck (2014), and that the validity is weak in the earliest stages of economic development in most of the OECD countries. Third, in fact, the extent to which the law is operational changes more frequently than shown by previous studies. This changing validity of the law also points to the possibility that the mixed results in earlier studies could be due to disregarding the structural changes accompanying each country's stage of economic development.

The rest of the paper is organized as follows. The next section describes the data used for this empirical analysis and overviews Wagner's law and the displacement effect. Section 3 explains our empirical framework and presents our empirical results. Section 4 concludes the paper.

2 Government size, economic development, and data

Studies in the literature test the displacement effect by investigating government size and verify Wagner's law by exploring the relationship between government size and economic development. However, according to a review by Peacock and Scott (2000), previous empirical studies dealing with Wagner's law use different measures for government size and economic development. One of the most commonly used representations is based on Musgrave (1969), who interprets the law as implying that the share of total government expenditure in GDP increases with per capita income (e.g., Lall, 1969; Mann, 1980; Ram, 1987; Islam, 2001; Chang, 2002; Chang et al., 2004; Shelton, 2007; Durevall and Henrekson, 2011). In regression formula, the specification can be represented as

$$GY = \alpha + \beta(PCY), \tag{1}$$

where GY is the share of government expenditure in GDP and PCY is the real per capita GDP.[5] In line with this thinking, we adopt GY as proxy for government size and PCY as proxy for economic development, and interpret the law as a positive effect of the latter on the former. Note that following many previous works, we transform both variables to the natural logarithmic form in this study.

As explained in the Introduction section, we need long historical data for as many countries as possible for our present work. Only recently, by assuming the Musgrave version of the law (or the above-mentioned two variables), the historical data for many countries could be obtained for a maximum period of approximately two centuries. Thus, we obtain annual observations for two series from recent studies, that is, GY from Mauro et al. (2013), and PCY from Barro and Ursúa (2008).[6]

Using the historical data of five western European countries, Kuckuck (2014) shows that Wagner's law is more valid when the GDP per capita is low than when it is sufficiently high. Given the World Bank's income group definitions, Kuckuck (2014) considers three development stages: (1) the "lower middle income stage" when the GDP per capita is less than 3,500 Int$, (2) the "upper middle income stage" when the GDP per capita is between 3,500 and 12,000 Int$, and (3) the "high income stage" when the GDP per capita is above 12,000 Int$. For comparison, following Kuckuck (2014), we refer to the same three development stages.[7]

Our dataset covers the following ten OECD countries: Australia, Canada, Chile, Denmark, Finland, Italy, Mexico, Sweden, the United Kingdom, and the United States. All the sample periods end in 2009, starting from as far back as possible. The list of countries, the corresponding periods, and the three development stages are reported in Table 1. As mentioned above, to evaluate the law at each development stage from an historical perspective, we need a long time span. Thus, the criterion for selecting the ten OECD countries is that their number of observations exceed 100 and the sample period be at least throughout the 20th century. An exceptionally selected country is Mexico. This is because a re-examination for Mexico appeared useful after some authors examined the law for Mexico among others. When defining the high income stage of the United States in accordance with Kuckuck's criterion, the threshold could be 1944, because the GDP per capita in the United States reached 12,000 Int$ temporarily in 1944 following a steep increase during World War

[5]See, for example, Durevall and Henrekson (2011) for why this specification appears proper when testing the law.

[6]The former data can be found on the website of International Monetary Fund (https://www.imf.org/external/pubs/cat/longres.aspx?sk=40222.0), and the latter, on Robert Barro's website (http://rbarro.com/data-sets/).

[7]Lall (1969) also focuses on development stages. While Kuckuck (2014) and this study rely on time series data, Lall (1969) analyzes the cross-sectional 1962–1964 averages data for 46 developing countries using per capita GNP to divide the countries into three income groups.

II. However, since it remained below 12,000 Int$ from 1945 to 1962, the threshold is defined as 1963, as reported in Table 1.

Before proceeding to our formal analysis, we overview the dynamics of GY and PCY over the last centuries in Figure 2. The shaded areas in the figure depict the above-mentioned three development stages (lower middle income, upper middle income, and high income). While generally both GY and PCY rise dramatically through the whole period in all countries, a few remarkable features can be observed.

First, large social and economic disturbances, such as World War I, World War II, and the Great Depression, have an extraordinary influence on GY and PCY in some countries in the short to medium term. Major peaks occur for GY in periods covering the two world wars. For the United States and some other countries, PCY falls in the aftermath of the Great Depression. Note that in the light of the long-run behavior, the level of GY remains much greater after the wars than immediately before the wars. This is consistent with the displacement effect proposed by Peacock and Wiseman (1961). As detailed in Section 3, the present wavelet methods enable us to exclude the short-run effects but capture the changing long-run behavior of GY.

Second, following the exclusion of Chile and Mexico, for whom the data of the high income stage are not available, GY shows little change in the latter part of the high income stage, unlike earlier, whereas PCY increases during the same period. A similar pattern appears for Chile from the latter part of the upper middle income stage to the early phase of the high income stage. Although this is not evident for Mexico, we confirm a small deviation between the two series in the latter part of the upper middle income stage. Thus, we observe that the spread between PCY and GY broadens in the recent decades in all countries, although some differences between the countries exist in timing and duration.

These simple visual results are consistent with the formal evidence for Sweden and the United Kingdom found by Durevall and Henrekson (2011), and for the United Kingdom, Denmark, Sweden, Finland, and Italy as shown by Kuckuck (2014). They also provide new evidence for the other countries, and we conjecture weak support for the law in recent decades in most countries.

Moreover, a comparison between the OECD countries indicates the possibility of country-specific timing. Durevall and Henrekson (2011) conclude that the law does not hold after roughly the mid-1970s for Sweden and the United Kingdom, but the timing seems uneven for the other countries. For example, for the United States in Figure 2, the deviation between PCY and GY for long-run movements appears to begin somewhere around the onset of the high income stage. In this connection, except for Chile and Mexico, the high income stages based on Kuckuck's (2014) criterion coincide roughly with the recent period of different evolutions of the two series. However, from Figure 2, the breaks are not necessarily formed in strict accordance with the onset of high income stages.

Third, except for Australia, for whom the lower middle income stage data are not available, while PCY rises during part of the lower middle income stage, GY exhibits low growth in the corresponding period. This indicates the possibility of Durevall and Henrekson's (2011) suggestion holding true in the earliest stage of economic development for not only Sweden and the United Kingdom but also for the other countries. While the authors argue that the law does not hold before roughly 1860 for Sweden and the United Kingdom, the timing of the breaks in other countries looks unlikely to be the same. Moreover, such breaks can hardly be expected to be only around the threshold year dividing the periods between the lower and upper middle income stages.

3 Time-frequency analysis

3.1 Methods and motivation

In this subsection, we briefly explain how to detect the displacement effect and the changing validity of Wagner's law over the centuries using wavelet analysis. Following Aguiar-Conraria et al. (2012) and Aguiar-Conraria and Soares (2014), we outline our wavelet tools below.

To begin with, we consider the basic functions called wavelet daughters $\tilde{\psi}$, which are obtained by scaling and translating the mother wavelet ψ:

$$\tilde{\psi}_{\tau,s}(t) = \frac{1}{\sqrt{|s|}}\psi\left(\frac{t-\tau}{s}\right), \quad s, \tau \in \boldsymbol{R}, s \neq 0, \tag{2}$$

where s is the scaling factor determining the width of the wavelet and concerns frequency, $1/\sqrt{|s|}$ is the normalization factor, and τ is the translation parameter determining the wavelet location in time. If $|s|$ is less (more) than 1, the wavelet is compressed (stretched). Note that, as specified below, the mother wavelet ψ is chosen to be a complex-valued function.

The continuous wavelet transform of a time series $x(t)$ can be described as

$$W_x(\tau, s) = \int_{-\infty}^{\infty} x(t)\tilde{\psi}^*_{\tau,s}(t)dt, \tag{3}$$

where the asterisk denotes complex conjugation. Note that wavelet transform $W_x(\tau, s)$ is considered complex-valued because ψ is assumed to be a complex-valued function, as already mentioned.

Regarding the mother wavelet for continuous wavelet transform, we follow previous studies in the literature such as Aguiar-Conraria et al. (2012), Rua (2012), Aguiar-Conraria and Soares (2014), Marczak and Gómez (2015), and many others, and assume the Morlet wavelet for $\omega_0 > 5$ such that

$$\psi_{\omega_0}(t) = \pi^{-1/4} e^{i\omega_0 t} e^{-t^2/2}. \tag{4}$$

Here, $\pi^{-1/4}$ is the normalization factor ensuring unit energy of the wavelet, i is an imaginary unit (i.e., $i = \sqrt{-1}$), and ω_0 is the parameter determining frequency within the Gaussian envelope. In practice, to the best of our knowledge, all previous economic studies assume $\omega_0 = 6$, because the scaling factor s is approximately equal to the frequencies when $\omega_0 = 6$. Following the previous works, we also set ω_0 to be 6 in this study.

The amplitude of the wavelet transform can be a useful tool to measure the contribution to the variance of series $x(t)$ around each time and frequency. That is, from the amplitude of the wavelet transform, the wavelet power spectrum can be given by

$$WPS_x(\tau, s) = |W_x(\tau, s)|^2. \tag{5}$$

Unlike the classic power spectrum based on the Fourier transform, $WPS_x(\tau, s)$ indicates how the strength of the time series $x(t)$ is distributed in the frequency domain as well as in the time domain.

In order to assess Wagner's law, we need to explore the relationship between government size (GY) and the long-run real per capita GDP (PCY). To explain the implementation of this exploration, we consider two time series, denoted by $x(t)$ and $y(t)$. The cross wavelet transform for the two series is defined as

$$W_{xy}(\tau, s) = W_x(\tau, s) W_y^*(\tau, s).$$

This complex-valued transform yields the following two useful measures.

The first measure is wavelet coherency; this is based on the amplitude $|W_{xy}(\tau, s)|$, defined as

$$R_{xy}(\tau, s) = \frac{|S(W_{xy}(\tau, s))|}{\sqrt{S(|W_{xx}(\tau, s)|) S(|W_{yy}(\tau, s)|)}}, \tag{6}$$

where S is a smoothing operator in both time and frequency. In an analogy with the well-known correlation coefficient, one can interpret wavelet coherency as a localized correlation coefficient over time (reflected by τ) and across frequencies (reflected by s). Note that $R_{xy}(\tau, s)$ is calculated as an absolute value and hence cannot be less than 0 or more than 1 (i.e., $0 \leq R_{xy}(\tau, s) \leq 1$).

The second measure is the phase difference between x and y, ρ_{xy}, which is obtained from the phase angle of the cross wavelet transform

$$\rho_{xy}(\tau, s) = \tan^{-1}\left[\frac{\mathrm{Im}\{W_{xy}(\tau, s)\}}{\mathrm{Re}\{W_{xy}(\tau, s)\}}\right],$$

with $\rho_{xy} \in [-\pi, \pi]$, where Re and Im denote respectively the real and imaginary parts. The phase difference provides information about whether the variables are leading or lagging at the specified time and frequency. Following Aguiar-Conraria et al. (2012), Aguiar-Conraria and Soares (2014), and many others, we summarize the various possibilities of ρ_{xy} as follows. When $\rho_{xy} \in (-\pi/2, \pi/2)$, x and y move in phase (positive correlation) because ρ_x and ρ_y have nearly the same value with a small phase difference. In particular, if $\rho_{xy} = 0$ (i.e., $\rho_x = \rho_y$), we infer that x and y move exactly together and are completely and positively correlated; if $\rho_{xy} \in (0, \pi/2)$, x leads y because ρ_x is slightly larger than ρ_y and the phase of x is leading; and if $\rho_{xy} \in (-\pi/2, 0)$, y leads x. On the other hand, when $\rho_{xy} \in (\pi/2, \pi)$ or $\rho_{xy} \in (-\pi, -\pi/2)$, x and y move out of phase (negative correlation). In particular, if $\rho_{xy} = \pi$ or $\rho_{xy} = -\pi$, they move in anti-phase. In this case, x and y are completely and negatively correlated. If $\rho_{xy} \in (-\pi, -\pi/2)$, x leads y. This is because y falls (rises) after x rises (falls), thus indicating a negative relationship between x and y, with x leading. Finally, if $\rho_{xy} \in (\pi/2, \pi)$, y leads x.

In our applications, both these measures derived from the cross wavelet transform are useful to test Wagner's law. The wavelet coherency between GY and PCY, $R_{GY,PCY}$, indicates when the relationship between the two is strong. Note, importantly, that we cannot evaluate the validity of the law only from $R_{GY,PCY}$. Assuming that PCY determines GY, as modeled in (1) in previous works, PCY should be positively correlated with GY and should lead GY (i.e., $\rho_{GY,PCY} \in (-\pi/2, 0)$). In summary, as a measure of testing Wagner's law, wavelet coherency makes sense only if the phase difference between GY and PCY is between $-\pi/2$ and 0.

Furthermore, a comparison of the wavelet power spectrum of government size, WPS_{GY}, and the wavelet coherency between GY and PCY, $R_{GY,PCY}$, is useful to identify whether Wagner's law or the displacement effect is crucial to explain long-run government growth. If Wagner's law is relevant to the growth in GY, then the significant regions of $R_{GY,PCY}$ with PCY leading coincide with those of WPS_{GY} in the time-frequency space. In contrast, if the displacement effect plays a significant role in explaining the growth, such coincidences are not expected and the long-run increase around the period of crisis should show up as an upward shift in WPS_{GY} at lower frequencies.

Before presenting the results, we need to mention that the continuous wavelet transform of a finite-length time series yields border distortions. Like other transforms, the transformed values at the edges of sample periods are incorrectly determined. Such edge effects bring about unreliable results in regions called the cone of influence in the time-frequency plane.

3.2 Empirical results

Studies in the literature consider the displacement effect and Wagner's law to hold over the long run, but not at all time. This indicates that we need to investigate low-frequency rather than high-frequency components. Thus, we report the results by focusing on long-run frequencies, which are defined as frequencies lower than 8-year cycles in this study.[8] Because of the cone of influence, the maximum cycle length of the present long-run frequencies is 32 years. In what follows, although we omit the coherency and phase difference calculated for frequencies higher than 8-year cycles, they are highly volatile over time and are not informative.

Figure 3 shows the wavelet coherency and phase difference between GY and PCY for each country. The coherency results are shown on the upper panel of Figure 3 for each country. Note that the cone of influence is described as white lines and the results outside the lines are incredible. The phase difference results are shown on the lower panel. To capture the local relationships across time and frequencies and understand the results, we calculate the phase difference for two divided frequency bands: the cycles of periodicity between 8 and 16 years, and those between 16 and 32 years. The shaded area depicts the development stages. Moreover, Figure 4 shows the wavelet power spectrum of GY. We use the ASToolbox proposed by Luis Aguiar–Conraria and Maria Joana Soares for calculating wavelet measures.

Australia

Until the mid-1950s, a large high coherency region exists in the long-run (16–32 year) frequency band, although it is partly under the effect of the cone of influence. Importantly, from the beginning to the middle of the 20th century, the phase difference calculated for the 16–32 year frequency band is consistently located between $-\pi/2$ and 0, suggesting that the leading variable is PCY. This indicates that PCY determines GY in this period, implying that the law holds. Moreover, while the coherency is low from 1920 to the late 1960s, the phase difference calculated for the 8–16 year frequency band is generally between $-\pi/2$ and 0. These findings reveal

[8] Christiano and Fitzgerald (2003) and others consider business cycle frequencies as between 1.5 and 8 years. Hence, we define lower frequencies as long-run frequencies.

a structural break validating Wagner's law until the late 1960s (i.e., in the upper middle income stage), especially until the mid-1950s, but the law does not hold from the late 1960s to the present day (i.e., in the high income stage) in Australia.

This revelation is consistent with the findings of Chang et al. (2004), who examine the causal relationship between income and government spending over the period 1951 to 1996 in Australia but find no evidence in favor of the law. As pointed out by Lamartina and Zaghini (2011) and Kuckuck (2014), such a structural change in phase difference indicates that the validity of the law is weakened in the advanced stage of development in Australia as well. In particular, when detecting structural breaks, the subsample periods based on the World Bank's income group definitions adopted in Kuckuck (2014) are likely to be roughly appropriate to the case of Australia.

The wavelet power spectrum of GY indicates a significant region at the 16–32 year frequency band around the World War II period. Although we cannot understand the case of World War I owing to the cone of influence stemming from lack of sample period, this supports the displacement effect during the World War II period in Australia. However, since a significant region of the power spectrum coincides with that of coherency, we determine that the long-run growth in GY is primarily due to Wagner's law in Australia.

Canada

One can confirm that generally coherency is low in the long run in Canada, but at the 10% significance level in the 8–16 year frequency band, a few high coherency regions can be found: from 1890 to 1900, from 1910 to 1930, and from the mid-1970s to the mid-1980s.[9]

In the first high coherency phase in the last part of the 19th century, a phase difference is located between $-\pi$ and $-\pi/2$, suggesting strong negative correlation. Since the phase difference between $-\pi/2$ and 0 does not remain stable by the early 1900s, we determine that the law is unlikely to hold roughly during the lower middle income stage. In the second high coherency phase from 1910 to 1930, the phase difference is between $-\pi/2$ and 0. Furthermore, in the third high coherency phase from the mid-1970s to the mid-1980s, the phase difference is positive. Over the period from 1880 to the late 1950s, the phase difference for the 8–16 year frequency band is persistently located between $-\pi/2$ and 0. Despite the cone of influence in the recent decades, it moves between 0 and $\pi/2$ after the late 1950s. Thus, the validity of the law is weakened in Canada ahead of the threshold of the high income

[9] A large significant region exists in the recent decades, but it is subject to the cone of influence.

stage in 1970.

From the results for the 16–32 year frequency band, high coherency regions exist from 1930 to 1950. However, on the whole, the phase difference calculated for the 16–32 year frequency band moves persistently between 0 and $\pi/2$. Thus, we find no evidence of the law in the 16–32 year frequency band.

In summary, compared to Australia, Wagner's law holds at higher frequencies (cycles of periodicity between 8 and 16 years) in Canada. Further, from the above-mentioned findings, the law for Canada is validated roughly during the upper middle income stage. However, the valid phase is more strictly in the period up to the mid-1950s, implying that mis-specifications could arise from cointegration analyses on subsamples divided by the World Bank's income group definitions, as in Kuckuck (2014). Considering the high coherency, we provide strong evidence of the law particularly during the period from 1910 to 1930.

The results are consistent with Chang et al. (2004), who examine the relationship between income and public expenditure in Canada for the more recent period from 1951 to 1996 and find no evidence of the law.[10]

On the other hand, at lower frequencies (16–32 year frequency band), the wavelet power spectrum of GY indicates a significant region covering the wars and the Great Depression. More precisely, the World War I period is not included in the significant region at the 5% level. This implies that, as a visual inspection of Figure 2 would show, the displacement effect appears to be smaller through World War I than through World War II and the Great Depression in Canada. The most important point that can be confirmed at this point is that the frequencies at the significant region of the power spectrum are lower than those at which Wagner's law is valid, implying that the displacement effect can account for much of the growth in GY in Canada in the 20th century.

Chile

To the best of our knowledge, few studies have tested Wagner's law for Chile so far, but some results emerge. First, a region with significant coherency is located between 1910 and 1920 at long-run frequencies corresponding to cycles of periodicity between 8 and 16 years. In the 8–16 year scales, the phase difference lies between $-\pi/2$ and 0 from 1910 to 1920, indicating that Wagner's law is particularly valid in this decade. Second, a large region of statistically significant coherency can be found at the same frequency band for the period from 1960 to 1980. However, the

[10]On the other hand, our results do not support the findings of Ahsan et al. (1996), who limit the period to 1953–1988 and find that the law is valid in Canada. However, as stated by Chang et al. (2004), this finding could be due to the fewer samples observed, and seems open to question.

phase difference in the periodicity between 8 and 16 years is lower than $-\pi/2$ for these two decades, suggesting negative relationship between the two variables. After the mid-1990s, the phase difference is again located between $-\pi/2$ and 0. Further, at longer-run frequencies (corresponding to cycles of periodicity between 16 and 32 years), the phase difference is generally between $-\pi/2$ and 0 from 1930 to 1980. In summary, the law seems valid in Chile especially around the mid-20th century.

The wavelet power spectrum exhibits no significant region in the long run, but this does not mean that the displacement effect is rejected in Chile. Most importantly, as one would realize from Figure 2, a sudden increase in GY is unlikely to be observed in Chile. Thus, we cannot test the displacement effect in Chile.

Denmark

At frequencies corresponding to cycles of periodicity between 8 and 16 years, a large high coherency region exists in the period from the early 1930s to the mid-1950s, but the phase difference is outside the range between $-\pi/2$ and 0. On the other hand, from the phase difference for longer frequencies (corresponding to cycles of periodicity between 16 and 32 years), PCY seems to be leading from 1930 to 1980 on the whole. Although no high coherency can be observed at longer frequencies, these results support the law in Denmark only in this half a century (from 1930 to 1980).

Our outcomes support Kuckuck's (2014) findings of weak evidence of the law in the high income stage and provide more detailed description on the following aspects. First, our findings roughly support the law in the upper middle income stage (from 1908 to 1968), as suggested in Kuckuck (2014), and show that the validity changes over time even within the upper middle income stage in a precise sense. That is, from the present endogenously detected time span, the law is validated not from 1908, but from 1930. Second, weak evidence of the law is indicated not only in the high income stage, but also before 1930 and in the lower middle income stage.

One can find no strong support for the displacement effect in Denmark because no particularly high power spectrum exists around the war period and the Great Depression. Relatively high power can be found after 1975, consistent with the rapid increase in GY, as can be seen in Figure 2. These findings imply that the displacement effect is not a dominant cause of the growth in government size over the past century.

Finland

Around the 1910s, a significant region of coherency exists at 8–16 year periodicities, but the corresponding phase difference is positive and the law is unlikely to hold. Coherency takes relatively high values from the late 1930s to the mid-1970s at cycles between 8 and 16 years. The phase difference calculated for the 8–16 year frequency band lies between $-\pi/2$ and 0 only in this period. The phase difference calculated for the 16–32 year frequency band is generally located outside the range.

As for Denmark, we support Kuckuck's (2014) findings, but the period supporting the law turns out to be narrower than the upper middle income stage (from 1937 to 1978). We also find that the validity of the law emerges stronger in the middle of the sample period in Finland as well.

A high power spectrum can be seen at long-run frequency especially around the World War II period in Finland, but it is not significant. This provides formal evidence supporting the simple inspection of Figure 2 and shows that the displacement effect dominates the growth in Finnish government size over the past century. More importantly, a high power emerges at 16–32 year frequencies and does not overlap high coherency regions. Thus, for the most part, the growth in GY appears to be accounted for by the displacement effect in Finland.

Italy

In Italy, two significant high coherency regions exist at cycles between 8 and 16 years: from 1900 to 1920, and from the mid-1930s to the early 1950s. The latter is relevant to Wagner's law, because the phase difference calculated for the 8–16 year frequency band is persistently negative from 1930 to 1960. These results for the 8–16 year frequency band are important to understand Kuckuck's (2014) indication that Wagner's law is less validated in the high income stage from 1978. Throughout the period, at longer-run frequencies between 16 and 32 years, the phase difference ranges generally between $-\pi/2$ and 0, but the extent to which GY and PCY are linked changes over time. This means that at longer-run frequencies, coherency is relatively high from 1900 to 1960. In summary, the validity of the law emerges stronger in the middle of the sample period in Italy as well.

Since a significant region of the power spectrum is large and appears at long-run frequencies until roughly 1970, we cannot obtain conclusive evidence of the displacement effect. However, from Figure 2, the displacement effect seems to be supported around the World War II period, at least in Italy. In comparison with the frequencies at which Wagner's law is strongly supported, the significant region of the power spectrum is located in different regions. This suggest that the displacement effect is the primary factor behind the growth of GY in Italy.

Mexico

After the mid-1960s, a large region of significant coherency exists at long-run frequencies between 16 and 32 years, although partly from the effect of the cone of influence in recent decades. This period coincides with the upper middle income stage from 1964. At these long-run frequencies, the phase difference is between $-\pi/2$ and 0 over 1940–2000. We cannot obtain informative results at higher frequencies at cycles between 8 and 16 years because the corresponding phase differences frequently change over time.

These results support the well-cited paper of Mann (1980), who tests Wagner's law for Mexico over a maximum period, from 1925 to 1976. As far as the Musgrave version is concerned (using GY and PCY), Mann provides stronger evidence of the law in the subsample period from 1941 to 1976 than for the full sample from 1925 to 1976. Considering the structural change around 1940, as mentioned above, we can understand Mann's findings. Moreover, Iniguez-Montiel (2010) suggests that the law is valid for more recent times from 1950 to 1999. This is consistent with our findings indicating strong validity of the law after the mid-1960s.

A relatively high power spectrum can be found at long-run frequencies after 1975 in Mexico. As for Chile, no large disturbances can be observed in GY as depicted in Figure 2. Thus, we cannot test the displacement effect in Mexico. However, since the high power region coincides with that of coherency, Wagner's law appears to explain the growth in GY especially around the 1970s.

Sweden

Four significant high coherency regions can be found in the long run for Sweden. The first phase before 1830 is irrelevant because the phase difference is positive. On the other hand, at low frequencies between 8 and 32 years, the phase difference is approximately between $-\pi/2$ and 0 from the early 1840s to the early 1960s. In addition to Kuckuck's (2014) indication that Wagner's law is less validated in the high income stage from 1969, the validity is also weak in the first half of the 19th century. This is consistent with Durevall and Henrekson (2011), who analyze long-term data from the early 19th century and find that the law holds only between roughly 1860 and the mid-1970s.

Note that from our results, the extent to which the data are consistent with the law depends on time even during the period from 1860 to the mid-1970s. Recalling the three significant regions with high coherency during this period, we can conclude that the strongest evidence is obtained in more local periods from 1850 to 1880. In the other significant phases, the law is rejected from 1900 to 1920 and from the mid-1930 to 1950 because the phase difference is less than $-\pi/2$.

A slightly high power spectrum can be observed in Sweden during the period covering two social disturbances, the Great Depression and World War II. This is consistent with Figure 2, and it turns out that the displacement effect occurs owing to the two disturbances. Since Wagner's law is not supported in the first half of the 20th century, it is highly likely that the displacement effect plays a crucial role during in period.

The United Kingdom

In the long run, a significant large region of high coherency is found in the long run from the close of the 19th century to the early 1960s. This period coincides roughly with the upper middle income stage from 1885 to 1972. Moreover, phase differences are persistently between $-\pi/2$ and 0 during the upper middle income stage.

These findings support the positive evidence provided by Gyles (1991), Oxley (1994), Chang (2002), and Chang et al. (2004), all of them using observations included in the upper middle income stage. We also confirm that Wagner's law is less validated in the high income stage from 1973, as indicated in Kuckuck (2014), and find that the validity is also weak in the lower middle income stage.

While our results agree with Durevall and Henrekson's (2011) findings, which show that the law holds between roughly 1860 and the mid-1970s, we can extract more detailed evidence from the coherency. That is, the significant region of the coherency suggests that the law is particularly validated in more local periods spanning from the mid-1890s until 1960. This region spreads throughout the 8–32 year frequency band.

The power spectrum is significantly high at long-run frequencies around the interwar periods. The significant region is large especially during the World War I period. As seen in Figure 2, the displacement effect is larger in the World War I period than in the World War II period in the United Kingdom. Moreover, from Figure 2 we infer that it is unlikely that the significant power stemming from the displacement effect comes from the Great Depression. In comparison with the significant region of coherency, high power emerges at lower frequencies. Thus, we can determine that the displacement effect rather than Wagner's law contributes to the growth in GY, reinforcing the findings of Peacock and Wiseman (1961).

The United States

With regard to coherency, while one observes a significant region at all frequencies in recent decades, relatively high values are found intermittently in the long run before the close of the 20th century. Before the high income stage except for the period from 1880 to 1890, the phase difference calculated for the 8–16 year frequency band is persistently located between $-\pi/2$ and 0.

These results support the findings of Islam (2001), who limits the period to 1929–1996 and finds positive evidence of the law. During a large part of this period, the phase difference for the 8–16 year frequency band is between $-\pi/2$ and 0, and the effects are reflected in Islam's results. However, our results also suggest the possibility that the time period covered by Islam leads to failure of the appropriate test. That is, the selected period includes a structural break around 1970 and picking a subsample that ends in 1970 seems appropriate for Islam's analysis.

In the U.S. case, as Figure 2 shows, besides World War I, World War II, and the Great Depression, the U.S. Civil War could be relevant to the displacement effect. In the power spectrum, high power regions at long-run frequencies can in fact be found when all the large social disturbances occur. Unlike in other countries, the displacement effect due to the Great Depression can be very large in the United States. Moreover, the frequencies of the high power regions turn out to be different from Wagner's law frequencies. Thus, the displacement effects are more dominant than the law in the United States.

4 Conclusion

In this paper, we attempted to distinguish between Wagner's law and the displacement effect, both of which purport to explain the remarkable growth in government size in the past few centuries, using wavelet analysis. Cumulative evidence for the OECD countries seems to justify the conclusion that Wagner's law is supported for limited periods and that the long-run growth in government size cannot be adequately explained by the law. However, the displacement effect can account for the bulk of the long-run growth in government size in Canada, Finland, Italy, Sweden, the United Kingdom, and the United States.

While the evidence of Wagner's law is mixed in previous works, our wavelet results of coherency and phase difference are useful to redress this situation. We find numerous differences in timing and valid duration of the law among the OECD countries. Our main findings are summarized as follows.

First, our wavelet coherency results show that the law is validated for limited periods in all the ten countries. The extent to which the data are consistent with the law depends on the time, even for limited periods. Moreover, such timings of structural breaks vary considerably between countries. This can be a potential reason for the inconsistent results of previous studies, most of which probably analyzed various countries and periods without careful attention to the treatment of structural breaks.

Importantly, previous works specify the period to which the law is valid, but we find that the validity is changing even for specified periods. In other words, the wavelet coherency procedure reveals more local breaks than previous studies point out. We therefore emphasize that the law should be explored with greater care for structural breaks than treatments as in previous studies.

Second, in addition to such minute structural changes, our phase difference results indicate that similar patterns appear for most of the OECD countries, although several countries cannot be investigated due to lack of historical observations. Specifically, the validity of the law tends to follow an inverted U-shaped pattern with economic development in most of the OECD countries. That is, the law is less valid in the earliest stage of economic development as well as in the advanced stages. While the outcomes for Sweden and the United Kingdom confirm the findings of Durevall and Henrekson (2011), the outcomes for other countries form new evidence.

Third, our wavelet results show the frequency at which the law holds dominantly, based on which we classify the ten OECD countries into three groups. Canada, Chile, Finland, Italy, and Sweden form the first group, for whom strongest support for the law is observed in the 8–16 year frequency band. Australia, Denmark, and Mexico form the second group, for whom strongest support is confirmed in a longer frequency band (i.e., the 16–32 year frequency band). The third group consists of the United Kingdom and the United States. Strongly positive evidence supports the law for the entire frequency band in the long run (i.e., the 8–32 year frequency band).

Although this study demonstrates the importance of Wagner's law and the displacement effect, the two hypotheses obviously cannot fully account for the long-run growth in government size. Thus, additional explanations need to be pursued in a future research.

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Table 1: Country coverage and income stage

Country	Observations	Coverage	Lower middle income stage	Upper middle income stage	High income stage
Australia	109	1901-2009	-1871	1872-1969	1970-2009
Canada	140	1870-2009	1870-1904	1905-1969	1970-2009
Chile	150	1860-2009	1860-1945	1946-2004	2005-2009
Denmark	130	1880-2009	1880-1907	1908-1968	1969-2009
Finland	128	1882-2009	1882-1936	1937-1978	1979-2009
Italy	148	1862-2009	1862-1938	1939-1977	1978-2009
Mexico	93	1917-2009	1917-1963	1964-2009	—
Sweden	210	1800-2009	1800-1924	1925-1968	1969-2009
UK	180	1830-2009	1830-1884	1885-1972	1973-2009
US	210	1800-2009	1800-1891	1892-1962	1963-2009

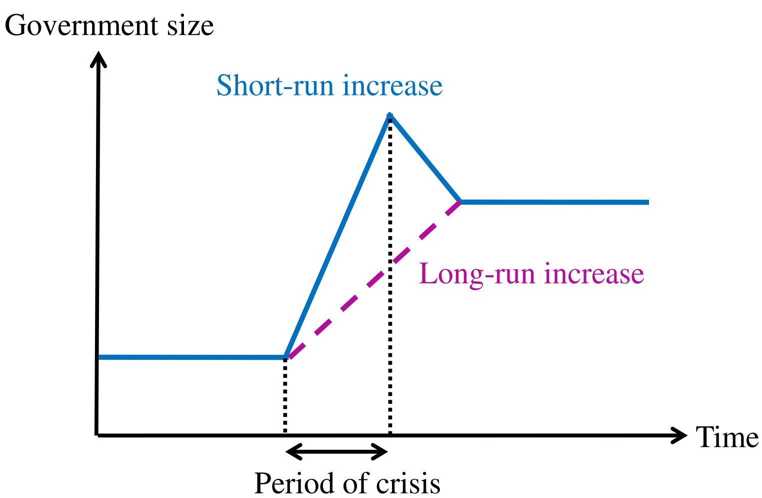

Figure 1: Displacement effect in the short and long run

Figure 2: Share of government expenditure in GDP (GY) and real income per capita (PCY) for ten OECD countries

Notes: The shaded areas depict the three development stages (lower middle income, upper middle income, and high income).

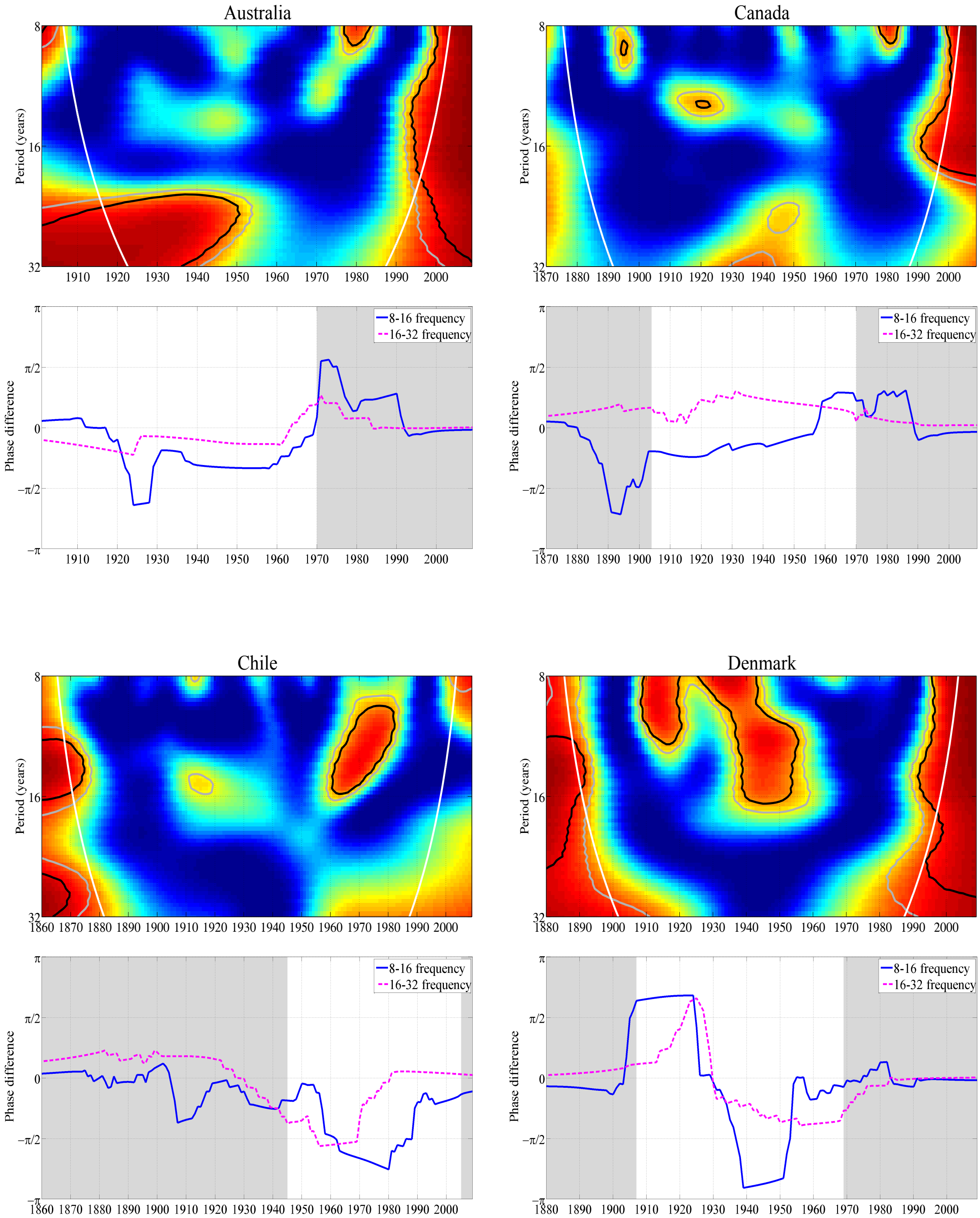

Figure 3: Coherency and phase difference between the share of government expenditure in GDP and GDP per capita

Notes: The upper panels depict the coherency ranges from blue (low coherency) to red (high coherency). The gray and black contours represent the 10% and 5% significance levels, respectively. The white line represents the cone of influence. The lower panels show the phase difference; the shaded area depicts the three development stages (lower middle income, upper middle income, and high income).

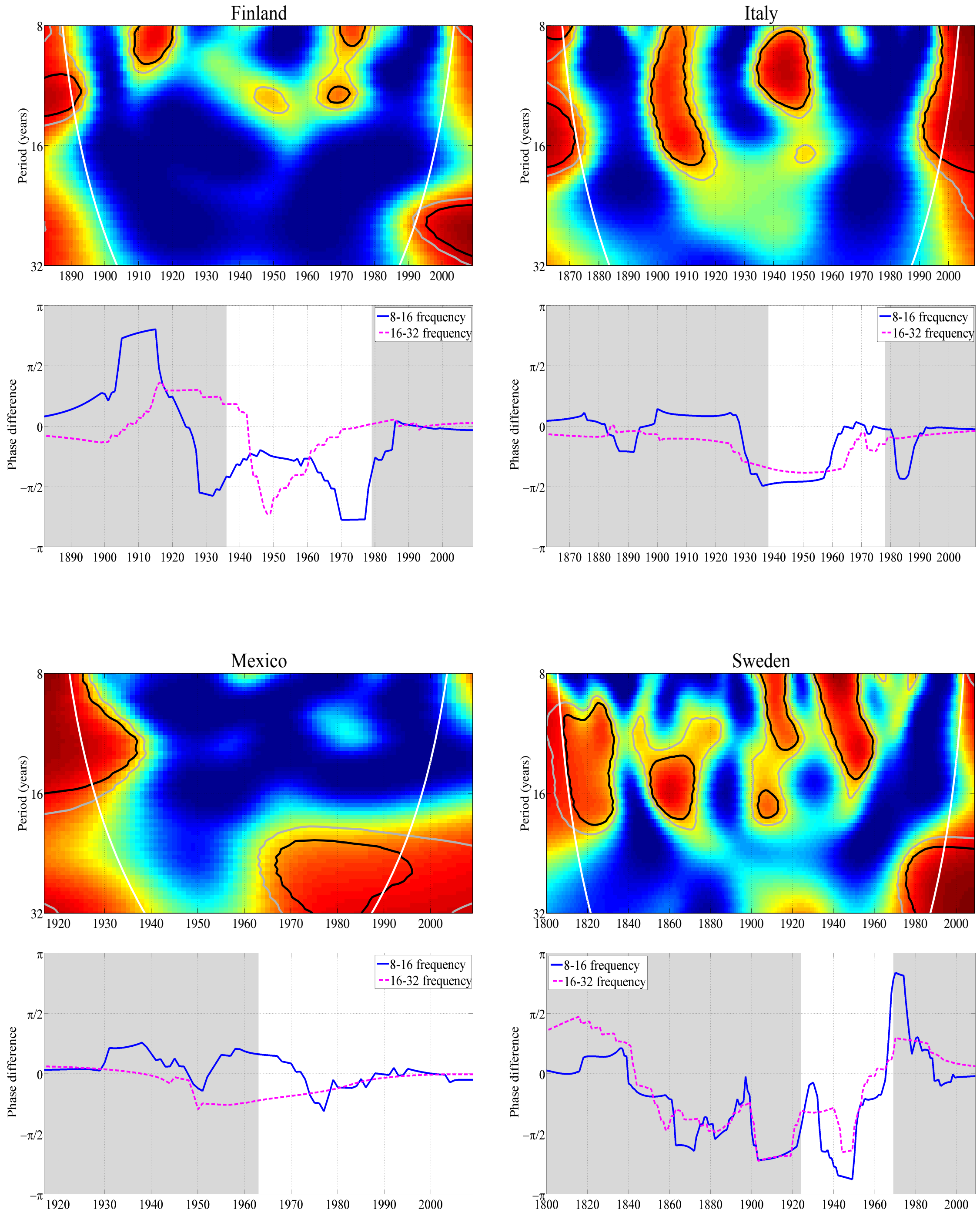

Figure 3: Coherency and phase difference between share of government expenditure in GDP and GDP per capita (Continued)

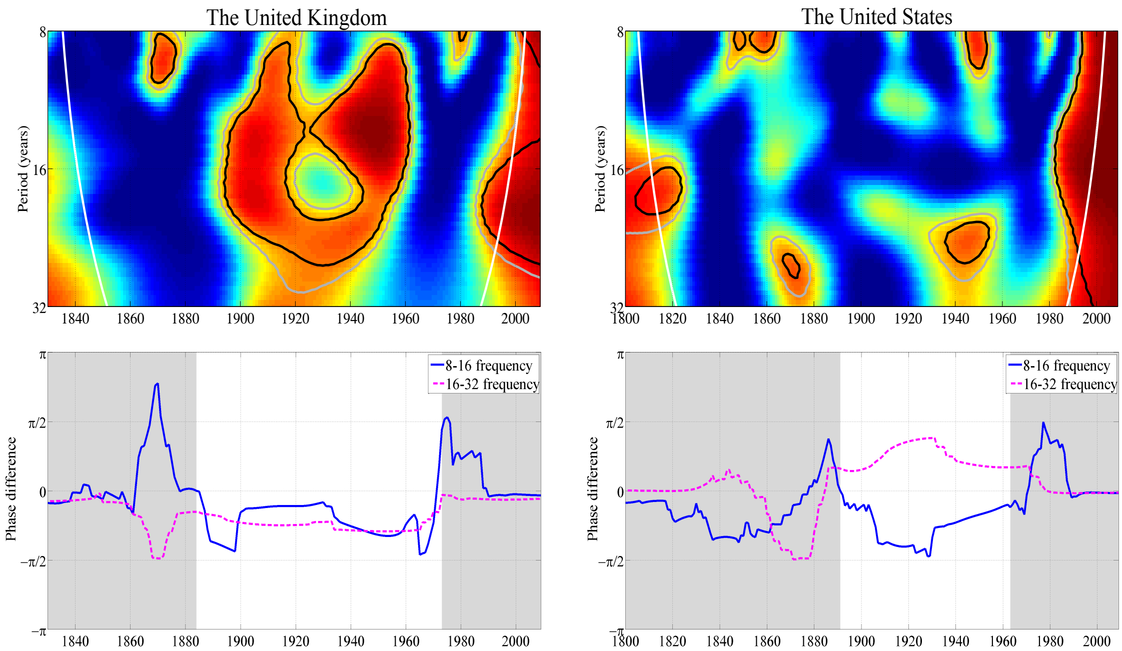

Figure 3: Coherency and phase difference between share of government expenditure in GDP and GDP per capita (Continued)

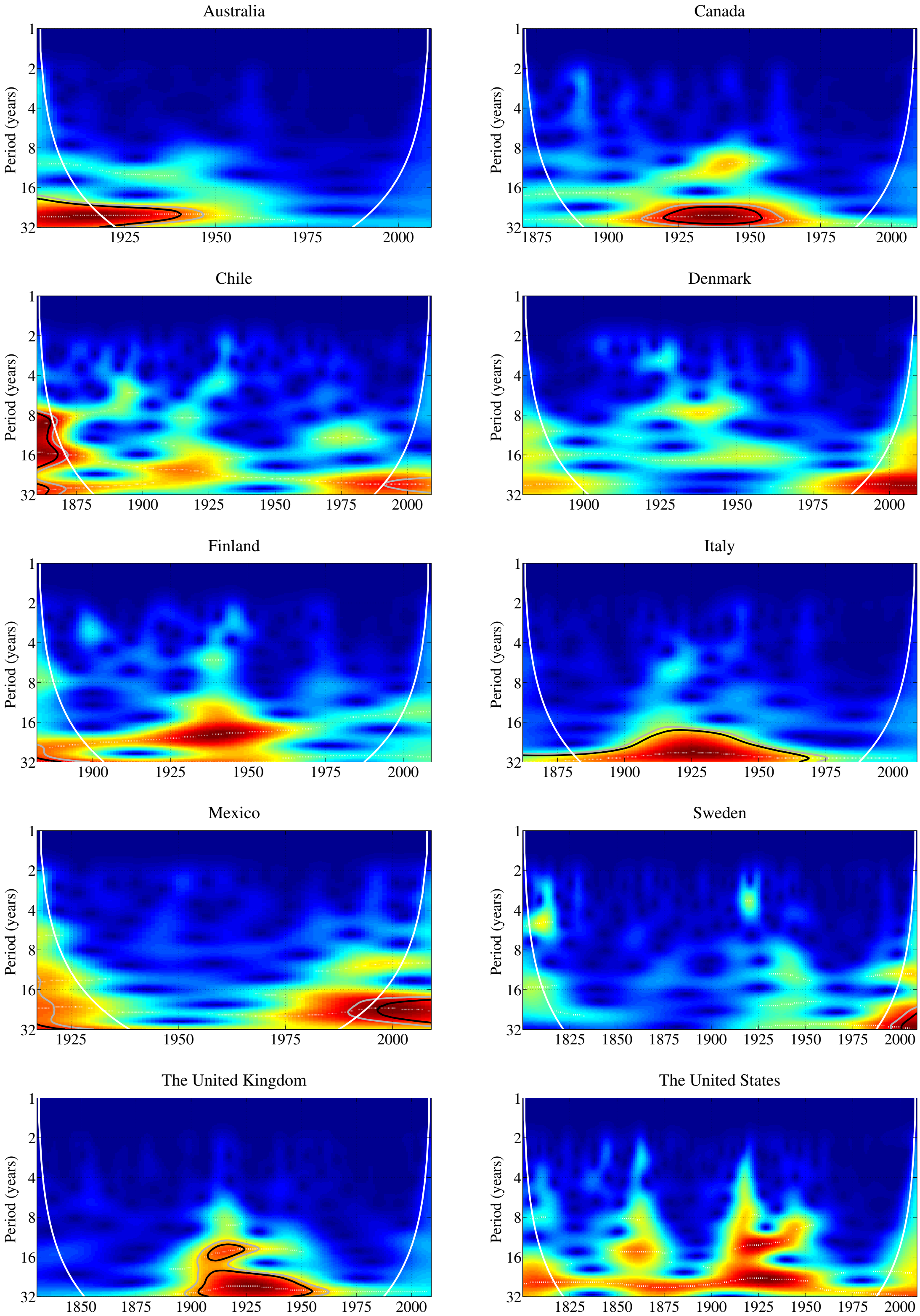

Figure 4: Wavelet power spectrum of government expenditure in GDP (GY) for ten OECD countries

Notes: The power spectrum ranges from blue (low power) to red (high power). The gray and black contours represent the 10% and 5% significance levels, respectively. The white dashed lines represent the maxima of the power spectrum. The white line represents the cone of influence.