



Friedman's plucking model: New international evidence from Maddison Project data

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ABSTRACT

Milton Friedman's plucking model of business cycles hypothesizes that deeper recessions forecast larger booms while stronger booms do not necessarily forecast deeper recessions. While most previous past empirical work is limited to post-war data in the US, this paper tests the plucking model using Maddison Project growth data for 169 countries across several centuries. We find that the plucking property is broadly evident across time and countries. Plucking is particularly strong in advanced economies in East Asia (Japan), Europe (Western Europe) and North America (US and Canada) while to a lesser extent elsewhere in emerging economies. The overall strength of the plucking property globally also appears to have increased during the 20th century with the rise of widespread industrialized economies.

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1. Introduction

There is a longstanding academic literature on the dynamics and symmetry of business cycles. Friedman (1964) first observed that there is asymmetry in the correlations between succeeding phases of the business cycle: the amplitude of a contraction is strongly correlated with the subsequent expansion although the amplitude of an expansion is uncorrelated with the amplitude of the subsequent contraction. Friedman (1993) extends this analysis to 7 additional countries beyond the US in the post-war period.

Goodwin and Sweeney (1993) and Sinclair (2009) similarly test for asymmetry of business cycle as implied by Friedman's "plucking" model.

Other papers introduce more formal modeling. Kim and Nelson (1999) are the first to introduce formal modeling finding that GDP fluctuations are well characterized by such a model. Dupraz et al. (2019) extend formal modeling into a New Keynesian framework with nominal rigidities and find that it fits U.S. NBER recession data well.

At most, the previous international evidence in the literature is limited to a few dozen business cycles during the post-war period

in advanced economies. This paper seeks to test the validity of the plucking model with greater sample size using Maddison Project data which has a much longer time horizon going back several centuries across many more countries that allows us to test for whether the plucking phenomenon is apparent more universally.

2. Recessions in annual maddison project real GDP per capita data

To measure asymmetries in the business cycle including the plucking property, we use the Maddison Historical Statistics Project of Bolt and van Zanden (2014), a collaborative project started in 2010 which compiles growth data from national accounts and various academic papers with historical growth estimates. In particular, this paper uses the "rgdpnnc" real GDP per capita variable from "Maddison Project Database, version 2018" from Bolt et al. (2018) as it is meant to match the per capita growth rate from the National Accounts. The annual growth data covers 169 countries for as far back as 1280 to 2016 with heterogeneity across countries with respect to data coverage (European countries like France and Sweden have the longest growth data histories going back to 1280 and 1300 respectively) amounting to 17,408 observations for which we have annual real per capita GDP growth data.

This paper defines a contraction as any period for which there is continuous annual negative per capita GDP growth following

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the convention for annual data used by the IMF including Rogoff et al. (2002), Kose and Terrones (2015) and Kose et al. (2020). Similarly, a boom is defined as any period for which there is continuous annual positive per capita GDP growth. Since we are comparing the amplitude of entire booms and entire contractions, we want to only examine complete contractions (which are bounded by years of positive per capita GDP growth) and complete booms (which are bounded by years of negative per capita GDP growth). Hence, any incomplete booms or incomplete recessions are discarded.

By this definition, we find 2697 complete contractions followed by complete booms and 2661 complete booms followed by complete recessions in our data.

3. Estimating the plucking model

We can think of contractions in terms of Markov chains with S_t being a state indicator variable (1 for a contractionary period and 0 otherwise) that determines the nature of the shocks to the economy evolving according to a first-order two-state Markov-switching process as in Hamilton (1989):

$$\Pr[S_t = 0 | S_{t-1} = 0] = q$$

$$\Pr[S_t = 1 | S_{t-1} = 1] = p$$

Similarly, the probability of entering a contraction can be modeled as:

$$\Pr[S_t = 1 | S_{t-1} = 0] = 1 - q$$

And the probability of exiting a contraction as:

$$\Pr[S_t = 0 | S_{t-1} = 1] = 1 - p$$

We are interested in measuring the degree to which the amplitude of a per capita GDP contraction forecasts the amplitude of the subsequent boom in per capita GDP while controlling for potential differences in plucking properties across countries. Hence, we estimate the following regression both with and without country fixed effects:

$$\text{BoomAmplitude}_{i,t+n} = \alpha + \gamma \text{ContractionAmplitude}_{i,t-1} + \mu_i + \varepsilon_{i,t} \tag{1}$$

where amplitude is defined as the percentage point per capita GDP growth over the duration of the boom or contraction.

In addition, we are similarly interested in measuring the degree to which the amplitude of a per capita GDP boom forecasts the amplitude of the subsequent contraction in per capita GDP while controlling for potential differences in plucking properties across countries. Hence, we estimate the following regression both with and without country fixed effects:

$$\text{ContractionAmplitude}_{i,t+n} = \alpha + \gamma \text{BoomAmplitude}_{i,t-1} + \mu_i + \varepsilon_{i,t} \tag{2}$$

Table 1a and Table 1b reports such results from estimating Eq. (1) without country fixed effects and with country fixed effects respectively. In the first specification within each table, all Maddison countries are pooled while additional specifications are run for different regions based on regional country classifications from the World Bank Atlas.

Note that the coefficients are largest (of around 2) for East Asia & Pacific, North America, and Europe & Central Asia which are all statistically significant at the 1% level, suggesting that a 1 percentage point larger contraction in GDP per capita is associated with a 2 percentage point larger successive boom in GDP per capita. These North America findings are consistent with past

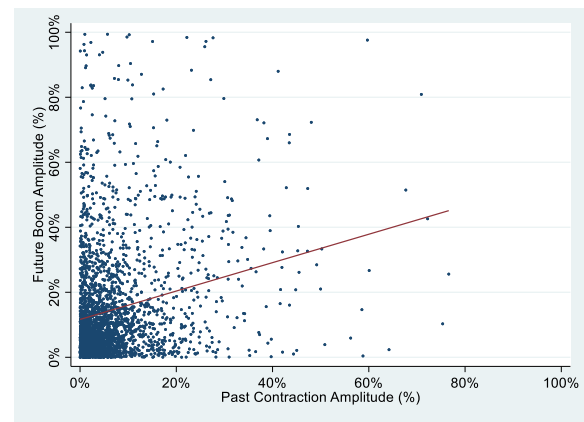


Fig. 1. GDP Per Capita Contraction Amplitude (%) Versus Successive GDP Per Capita Boom Amplitude (%).

plucking findings that are limited to US data. These other cross-regional plucking findings are consistent with Friedman (1993) which examines post-war data in fewer developed countries, only in the post-war period. Notably, the Europe & Central Asia and North America specifications both have substantially high R^2 values between 0.2 and 0.3 (similar to how Dupraz et al., 2019 find high R^2 values in their analysis of U.S. data). Interestingly, plucking seems to be less strong in Sub-Saharan Africa, Middle East & North Africa, South Asia and Latin America & Caribbean with smaller plucking coefficients between 0.3 and 1.

It appears that the plucking property is strongest among advanced economies. Within East Asia, the coefficients for advanced economies like Japan tended higher while coefficients for emerging countries like China tended lower. Within Europe, the coefficients for advanced economies in Western Europe like France tended higher while coefficients for emerging countries in Eastern Europe like Russia tended lower. Within North America, the coefficients for advanced economies like the US and Canada tended higher while the coefficients for emerging economies like Mexico tended lower.

The overall strength of the plucking property globally also appears to have increased during the 20th century with the rise of widespread industrialized economies. The fixed effects coefficient using all country data prior to 1800 was 0.320 ($n = 439$), while the coefficient from all country data between 1800 to 1899 was 0.435 ($n = 496$), and the coefficient from all country data between 1900 to 2016 was 1.357 ($n = 1762$). Fig. 1 also plots contraction amplitudes against successive boom amplitudes.

Table 2a and Table 2b reports such results from estimating Eq. (2) without country fixed effects and with country fixed effects respectively. Different specifications for all Maddison countries-pooled and different World Bank Atlas regions are also run. Fig. 2 also plots boom amplitudes against successive contraction amplitudes.

Note that most coefficients are near zero and are not statistically significant, in line with Friedman's plucking theory (which predicts that boom amplitudes cannot accurately forecast successive contractions).

4. Conclusion

To summarize, the Maddison database with some of the most comprehensive growth data available provides further empirical support for the plucking model of business cycles across countries and across time. It also shows that plucking has become increasingly stronger in the 20th century and is particularly

Table 1a
Forecasting power of real GDP per capita contractions on real GDP per capita booms (Ordinary least squares).

BoomAmplitude _{t+n}	All	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
ContractionAmplitude _{t-1}	1.430 *** (0.122)	2.217 *** (0.588)	2.017 *** (0.125)	0.278 ** (0.124)	0.975 (0.693)	1.713 *** (0.342)	0.470 ** (0.204)	1.000 *** (0.383)
α (Constant)	0.114 *** (0.015)	0.161 *** (0.062)	0.068 *** (0.015)	0.145 *** (0.013)	0.321 *** (0.120)	0.089 *** (0.029)	0.108 *** (0.022)	0.108 ** (0.049)
Country fixed effects	No	No	No	No	No	No	No	No
N	2,697	249	1,082	561	187	62	88	468
R ²	0.05	0.05	0.19	0.01	0.01	0.30	0.06	0.01

Notes: ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, *indicates statistical significance at the 10% level. Regional country classifications are based upon the World Bank Atlas.

Table 1b
Forecasting power of real GDP per capita contractions on real GDP per capita booms (Country fixed effects).

BoomAmplitude _{t+n}	All	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
ContractionAmplitude _{t-1}	0.569 *** (0.028)	2.249 *** (0.608)	1.902 *** (0.131)	0.288 ** (0.123)	0.866 (0.750)	1.573 *** (0.343)	0.373 * (0.215)	0.829 ** (0.395)
α (Constant)	0.123 *** (0.015)	0.159 *** (0.061)	0.076 *** (0.015)	0.148 *** (0.013)	0.332 *** (0.123)	0.097 *** (0.029)	0.114 ** (0.022)	0.122 ** (0.049)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,697	249	1,082	561	187	62	88	468
R ²	0.05	0.05	0.19	0.01	0.01	0.30	0.06	0.01

Notes: ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, *indicates statistical significance at the 10% level. Regional country classifications are based upon the World Bank Atlas.

Table 2a
Forecasting power of real GDP per capita booms on real GDP per capita contractions (Ordinary least squares).

ContractionAmplitude _{t+n}	All	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
BoomAmplitude _{t-1}	0.001 (0.003)	0.003 (0.007)	-0.008 (0.007)	0.007 (0.014)	-0.004 (0.008)	0.055 (0.040)	-0.028 (0.057)	0.008 (0.006)
α (Constant)	0.073 *** (0.002)	0.063 *** (0.005)	0.072 *** (0.003)	0.067 *** (0.004)	0.101 *** (0.012)	0.043 *** (0.011)	0.062 *** (0.012)	0.084 *** (0.005)
Country fixed effects	No	No	No	No	No	No	No	No
N	2,661	248	1,073	554	182	62	87	455
R ²	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00

Notes: ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, *indicates statistical significance at the 10% level. Regional country classifications are based upon the World Bank Atlas.

Table 2b
Forecasting power of real GDP per capita booms on real GDP per capita contractions (Country fixed effects).

ContractionAmplitude _{t+n}	All	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
BoomAmplitude _{t-1}	-0.004 (0.003)	0.001 (0.007)	-0.023 *** (0.007)	0.007 (0.015)	-0.006 (0.008)	0.037 (0.042)	-0.089 (0.057)	0.005 (0.006)
α (Constant)	0.084 *** (0.005)	0.063 *** (0.005)	0.075 *** (0.003)	0.067 *** (0.004)	0.102 *** (0.011)	0.046 *** (0.011)	0.070 *** (0.012)	0.085 *** (0.005)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,661	248	1,073	554	182	62	87	455
R ²	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00

Notes: ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, *indicates statistical significance at the 10% level. Regional country classifications are based upon the World Bank Atlas.

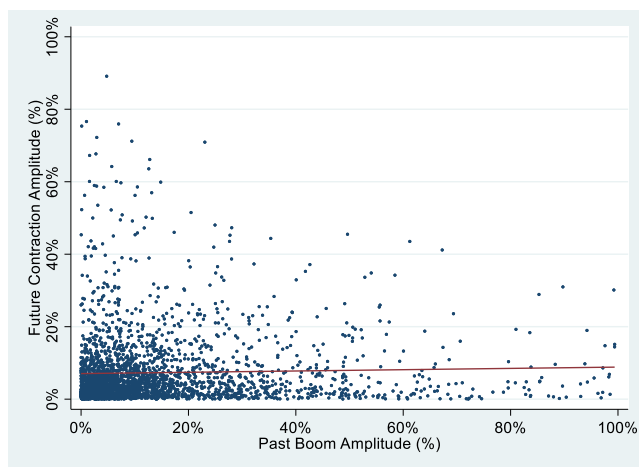


Fig. 2. GDP Per Capita Boom Amplitude (%) Versus Successive GDP Per Capita Contraction Amplitude (%).

strong among advanced economies. The plucking phenomenon also has implications for fiscal policymakers, central bankers and macroprudential policymakers, namely that they should generally avoid pre-emptive policy tightening to slow down a booming economy. Instead, the plucking model suggests policymakers should generally implement accommodative policy after downturns have become apparent since the timing and magnitude of these contractions is difficult to forecast with data from the current expansion's amplitude.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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