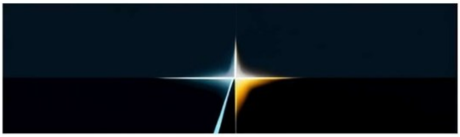

A THEORY ON SPECIFYING RESOURCE ALLOCATION DYNAMICS IN LONG-TERM MULTIDIMENSIONAL PUBLIC POLICIES

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Stylit

By the same author

In English

The European Union policy for vocational education and training. Stylit, 2022. ISBN 9789523901674

CVET in Europe: the way ahead. Cedefop, Publications Office of the European Union, Luxembourg, 2015. ISBN 9789289619240

Cultural and social diversity and the transition from education to work (Ed.). Springer, 2013. ISBN 9789400751064

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Les marchés de capitaux. Litec, 1992. ISBN9782711122103

Author's website
https://gtsite.xyz/1/

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To cite this book

Guy Tchibozo (2024). *A theory on specifying resource allocation dynamics in long-term multidimensional public policies*. Stylit.

Published in January 2024 by

Stylit

Tampere (Finland)

www.stylit.net

ISBN 978-952-390-600-6

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TABLES

1. INTRODUCTION

1.1. Definitions

In this book, a policy is defined as a set of objectives, actions to achieve them, and resources to support them. Resources can be of any kind, be they human, financial, material, legal, or institutional. A policy is public if it is developed at the initiative and under the direct control of the governing body of a territory or of an intergovernmental organization.

In this book, a policy is considered multidimensional if the actions it takes are of differentiated types. The differentiation lies in the nature of the intervention tool (e.g. subsidies, tax measures, service provision) and/or the target population (e.g. groups differentiated by age, gender, place of residence, etc.). For example, a family policy that consists solely of granting families particularly high family allowances upon the birth of a third child irrespective of any other consideration, such as the parents' income or marital status, is one-dimensional. On the other hand, the policy is multidimensional if it also includes other types of action, for example in terms of creating day-care centers (a different intervention tool) or guaranteeing equal rights to professional promotion for women on maternity leave (differentiation of both the intervention tool and the target group).

In this book, a policy is considered long-term if its implementation requires several decades. For example, policies aimed at reversing demographic trends or changing public opinion (e.g., on the death penalty or immigration) cannot be expected to achieve their objective in the space of just a few years. In general, long-term policies require a transformation of underlying social and cultural structures that can take considerable time. It is worth noting that the need for a long timeframe is not always inherent in the policy itself. A policy considered short-term in one country (for example, vaccinating most of the population in the face of a pandemic) may be considered long-term in another, due to a lack of resources.

1.2. Purpose

There is a wide variety of long-term multi-dimensional public policies (LTMDPs). Contemporary examples include policies aimed at:

- Industrializing or re-industrializing countries,
- Implementing or modernizing countries' key infrastructures,
- Substituting fossil energy with green energy,
- Protecting the natural environment,
- Adapting to climate change,
- Implementing sustainable development,
- Coping with demographic ageing and depopulation,
- Addressing social inequalities,
- Repopulating the teaching profession,

- Redesigning and updating healthcare systems,
- Implementing gender pay equity,
- Handling international migration flows,
- Restructuring national defense systems,
- And rethinking the police (a challenge in almost every country).

Specifying the dynamics of resource allocation in an LTMDP means identifying whether and how the allocation of resources to this policy's strands has followed a pattern of stability or instability over a given period. Allocation is decided within the framework of budgetary arbitration, in the process of determining the amount of budget to be granted to each strand of the policy.

It is well known that budgetary distribution is often characterized by stability, due to the inertia that leads to the same budget shares being repeated from one year to the next, with only marginal adjustments where necessary. In addition, allocating a stable budget to a policy strand over time can serve to lend credibility to the idea that the public authorities are making a firm and lasting commitment to the area under consideration. This is meant to give confidence to stakeholders and encourage them to implement actions that contribute to the achievement of the intended policy objectives.

However, policymakers may prefer instability.

First, certainty can encourage stakeholders to pursue strategies that policymakers might not want, especially rent seeking — see for instance Mulligan (2018) for a recent reconsideration of this concept.

More generally, instability enables policymakers to underline their strategies. Instability thus reflects the evolution of political intentions and orientations through marked changes, including dramatic shifts or "punctuations" as termed by Baumgartner and Jones (2009).

Not being bound to allocation stability also gives policymakers leeway to responsively react to rapidly changing political priorities or population needs, or to social, economic, environmental, health, geopolitical or other crises.

However, controlling the stability or instability of resource allocation may also simply be out of reach, as is the case, for example, with the inflow of external funds in aid-receiving developing countries (e.g., Bulir & Lane, 2006).

The point in this book is not to determine whether resource allocation *should* be stable or not. It is to measure whether resource allocation in policy strands *has been* stable or unstable over a period of policy implementation, and to quantify the characteristics of stability or instability, as this may be important when it comes to understanding the outcomes of the policy.

One obvious argument in favor of such importance is that there is no reason to assume that changes in resource allocation, funding interruptions, staff cuts, or the occasional injection of massive funds, are inherently without effect on policy failure or success. On the contrary, it is because a positive effect on the success of a given policy is expected that the funding or staff resources allocated to that policy are increased.

Therefore, precise identification of how resource allocation is stable or unstable is important for policy analysis.

This book is an introductory attempt towards the systematic identification of the patterns of resource allocation dynamics in long-term multi-dimensional public policies.

Policy analysis is usually not approached from the angle of LTMDPs as defined here. Nor is it common to pay attention to the systematic analysis of the dynamics of resource allocation in LTMDPs, or in policies in general.

1.3. Related literature

Building on Knight's (1921) concept of uncertainty, economic theory has long studied policy uncertainty. Research has also devoted attention to uncertainty (and surprise) in monetary, banking, fiscal, trade, health, and climate policies, among others. However, while there may be a link between the stability or instability of policy funding and policy uncertainty, the question of the dynamics of funding, or resource allocation more generally, and its role, has not been studied.

Over the past decade, Baker et al. (2016) have developed a seminal methodological work to measure (the feeling of) economic policy uncertainty (EPU). Based on newspaper coverage, tax code provisions, and surveys of professional forecasters, Baker, Bloom, and Davis established an EPU index that has inspired a whole range of subsequent research. However, this approach does not identify the sources of uncertainty, just the uncertainty, and therefore ignores resource allocation and its potential role in uncertainty.

Another related line of research is that of resource allocation in public policy. Over the past two decades, this literature has focused on various aspects, including, in particular, resource allocation from the perspective of place-based policies (e.g., Bartik, 2020), the equity-efficiency-ideology trade-off (e.g., Castells & Solé-Ollé, 2005), and the effects of allocation choices (e.g., Cohen et al., 2011; Gaubert et al., 2021). However, the analysis of the dynamics of resource allocation has been overlooked in this literature as well.

Finally, nor has the literature on budgetary processes addressed this topic. Over the past two decades, authors in this area have prominently investigated the increasing concern and pressure for budgetary discipline, performance, and efficiency (e.g., Podger et al., 2018; Wanna et al., 2015) and the rise of new approaches in public budgeting (e.g., Ayse Sahin Ipek, 2019). However, the dynamics of resource allocation have not been addressed here either.

1.4. Book structure

In the next two chapters of this book, a method for characterizing the patterns of resource allocation dynamics in LTMDPs will first be proposed. Next, a numerical example will be presented. Finally, the conclusion will outline some of the stakes and prospects for research in this field.

The characteristic feature of the proposed method for specifying the dynamics of resource allocation in LTMDPs is the use of secondary standard deviations (section 2.2 below). For this reason, the method is referred to as the "SSD method". Variants of this method have been presented and used in other works, especially in the area of the transition of university graduates from education to work (Tchibozo, 2004, 2023a).

2.1. Degree of stability or instability in resource allocation

Let us consider an LTMDP. Each year, a budget is allocated to each strand (“dimension”) of the policy. Each year can thus be characterized in terms of the budget distribution to strands, i.e., by a vector of budget distribution. For example, year t can be represented by a vector $\vec{v}_t$ such as:

$$\vec{v}_t = (y_t^A,\ y_t^B,\ \cdots,\ y_t^M) \tag{1.1}$$

where A, B, …, M represent the dimensions of the policy, and y_t^m is the budget allocated to dimension m in year t.

The budget distribution over the whole of the period under consideration can be described by a matrix J such as:

$$J = \begin{pmatrix} y_1^A & y_1^B & \cdots & y_1^M \\ y_2^A & y_2^B & \cdots & y_2^M \\ \vdots & \vdots & \vdots & \vdots \\ y_T^A & y_T^B & \cdots & y_T^M \end{pmatrix} \quad (1.2)$$

where T is the last year of the period.

For each dimension m, the coefficient of variation of the annual budget series is an indicator of the dispersion of annual budgets over the period. The coefficient of variation for dimension m is denoted c^m and is defined by:

$$c^m = \frac{\sigma^m}{\overline{y^m}} \quad (1.3)$$

where

- $\sigma^m = \sqrt{\frac{\sum_{t=1}^{T}\left(y_t^m - \overline{y^m}\right)^2}{z}}$ is the standard deviation of the series of annual budgets allocated to dimension m,
- $\overline{y^m} = \frac{\sum_{t=1}^{T} y_t^m}{z}$ is the average annual budget for dimension m over the entire period,
- and z is the total number of annual budgets over the period.

The lower the coefficient of variation for a strand, the more stable the amounts of annual budget allocated to that strand over the period. A coefficient of variation is equal to zero if the budget amount allocated to the strand is exactly the same from one year to the next.

The coefficient of variation therefore makes it possible to identify whether resource allocation in a strand has been governed by strict stability, or low, moderate, or marked instability. The size of the coefficient of variation does not depend on the size of the budgets since the standard deviation is weighted by the mean. The coefficient of variation can therefore be used to compare dispersion between dimensions.

However, there is no theoretical definition of the numerical instability thresholds (low, moderate, or marked instability) in this research area. Empirical research will be needed to calibrate instability thresholds correctly.

2.2. Trends in resource allocation instability

When budget allocation in a dimension is unstable, it is possible to assess whether the observed instability has an upward or downward trend. One possible approach is to calculate the standard deviations for each pair of consecutive years (primary standard deviations, *PSDs*), and then the standard deviations for each pair of consecutive *PSDs* (secondary standard deviations, *SSDs*).

The vector of primary standard deviations, denoted $\overrightarrow{PSD^m}$, is:

$$\overrightarrow{PSD^m} = \begin{pmatrix} psd_2^m = \sqrt{\frac{\left[y_1^m - \left(\frac{y_1^m + y_2^m}{2}\right)\right]^2 + \left[y_2^m - \left(\frac{y_1^m + y_2^m}{2}\right)\right]^2}{2}} \\ psd_3^m = \sqrt{\frac{\left[y_2^m - \left(\frac{y_2^m + y_3^m}{2}\right)\right]^2 + \left[y_3^m - \left(\frac{y_2^m + y_3^m}{2}\right)\right]^2}{2}} \\ psd_4^m = \sqrt{\frac{\left[y_3^m - \left(\frac{y_3^m + y_4^m}{2}\right)\right]^2 + \left[y_4^m - \left(\frac{y_3^m + y_4^m}{2}\right)\right]^2}{2}} \\ \vdots \\ psd_T^m = \sqrt{\frac{\left[y_{T-1}^m - \left(\frac{y_{T-1}^m + y_T^m}{2}\right)\right]^2 + \left[y_T^m - \left(\frac{y_{T-1}^m + y_T^m}{2}\right)\right]^2}{2}} \end{pmatrix} \quad (1.4)$$

where

- psd_2^m is the primary standard deviation calculated for the period running from the first-year allocation to the second-year allocation in strand m,
- psd_3^m is the *PSD* for the period from the second-year allocation to the third-year allocation,
- and so on.

The vector $\overrightarrow{SSD^m}$ of secondary standard deviations is:

$$\overrightarrow{SSD^m} = \begin{pmatrix} ssd_3^m = \sqrt{\dfrac{\left[psd_2^m - \left(\frac{psd_2^m + psd_3^m}{2}\right)\right]^2 + \left[psd_3^m - \left(\frac{psd_2^m + psd_3^m}{2}\right)\right]^2}{2}} \\ ssd_4^m = \sqrt{\dfrac{\left[psd_3^m - \left(\frac{psd_3^m + psd_4^m}{2}\right)\right]^2 + \left[psd_4^m - \left(\frac{psd_3^m + psd_4^m}{2}\right)\right]^2}{2}} \\ ssd_5^m = \sqrt{\dfrac{\left[psd_4^m - \left(\frac{psd_4^m + psd_5^m}{2}\right)\right]^2 + \left[psd_5^m - \left(\frac{psd_4^m + psd_5^m}{2}\right)\right]^2}{2}} \\ \vdots \\ ssd_T^m = \sqrt{\dfrac{\left[psd_{T-1}^m - \left(\frac{psd_{T-1}^m + psd_T^m}{2}\right)\right]^2 + \left[psd_T^m - \left(\frac{psd_{T-1}^m + psd_T^m}{2}\right)\right]^2}{2}} \end{pmatrix} \quad (1.5)$$

where

- ssd_3^m is the secondary standard deviation for the sub-periods from the first-year allocation to the third-year allocation,
- ssd_4^m, the *SSD* for the sub-periods from the second-year allocation to the fourth-year allocation,
- and so forth.

The logarithm of the average growth index of the secondary standard deviations, denoted L_{SSD}, can then be calculated:

$$L_{SSD}^{m} = ln\left(\sqrt[T-3]{\prod_{t=3}^{T-1} ssd_{t+1}^{m}/ssd_{t}^{m}}\right), ssd_{t}^{m} > 0 \quad (1.6)$$

As standard deviations cannot be negative, neither can the average growth index of secondary standard deviations. Due to the restriction $ssd_t^m > 0$, it cannot be zero either.

$L_{SSD} < 0$ when the average growth index of the secondary standard deviations is less than 1, i.e., when the secondary standard deviations are decreasing over the period. In this case, the instability is reducing.

$L_{SSD} = 0$ when the average growth index of the secondary standard deviations is equal to 1, i.e., when the secondary standard deviations are constant over the period. In this case, the instability remains at a constant level, neither increasing nor decreasing.

$L_{SSD} > 0$ when the average growth index of the secondary standard deviations is greater than 1, i.e., when the secondary standard deviations are increasing over the period. In this case, the instability is growing.

L_{SSD} cannot be calculated if $ssd_t^m = 0$, which is the case if the budget series for the period contains at least one triplet of consecutive annual budgets such that the budget for the second year is equal to the average of the first- and third-year budgets (see Appendix 1 for explanation).

Instability trends of different dimensions can be compared. Let's keep in mind that since $ln(x)$ is a monotonically increasing function in x:

$$\text{If } a > 0 \text{ and } b > 0,\ a < b \Leftrightarrow ln(a) < ln(b)$$

Hence, the higher the positive value of L_{SSD} in a dimension, the faster the growth of instability in that dimension. And the lower the negative value of L_{SSD} in a dimension, the faster the decrease in instability in that dimension.

2.3. Trends in budget amounts

Of course, the trend – decreasing, static, or increasing – of the budgets allocated to a strand can also be determined. While this can be approached through plotting a graph of the budget data or estimating the constant in a regression model adjusted on the budget data, it is also possible, alternatively, to calculate the logarithm of the geometric average of the annual growth indices of the budgets, denoted L_G:

$$L_G^m = ln\left(\sqrt[T-1]{\prod_{t=1}^{T-1} y_{t+1}^m / y_t^m}\right),\ y_t^m > 0 \qquad (1.7)$$

As budgets cannot be negative, the geometric average of their growth indices cannot be negative either.

$L_G^m < 0$ when the average growth index, although strictly positive, is less than 1. In this case, the annual budget of dimension m decreases year after year over the period, or any increase in the annual budget at one point in time is (over)compensated by a decrease in the annual budget at other points in time.

$L_G^m = 0$ when the average growth index is equal to 1. In this case, the annual budget of dimension m is strictly constant year after year over the period, or increases in the annual budget at some points in time are exactly offset by decreases at other points in time.

$L_G^m > 0$ when the average growth index is greater than 1. In this case, the annual budget of dimension m increases year after year over the period, or any reduction in the annual budget at one point in time is (over)compensated by growth in the annual budget at other points in time.

As the *ln* function is only defined on the interval $]0, +\infty[$, L_G^m cannot be calculated if at least one annual budget entered in the calculation is equal to 0.

The higher the positive value of L_G in a dimension, the faster the budget growth in that dimension. The smaller the negative value of L_G in a dimension, the faster the budget decrease in that dimension.

2.4. Summary table

To sum up, the results of calculations can be wrapped up as shown in Table 2.1 below.

Table 2.1
Presentation of analysis results

MEASUREMENT METHOD AND RESULT INTERPRETATION	DIMENSIONS		
	A	…	*M*
Trends in budget amounts Measured based on the average growth indices of budgets *Increasing – Static – Decreasing*			
Degrees of stability or instability in budget allocation Measured based on coefficients of variation *Strict stability – Low / Moderate / Marked instability*			
Trends in budget allocation instability Measured based on average growth indices of secondary standard deviations *Increasing – Constant-level – Decreasing*			

3. NUMERICAL EXAMPLE

The following example illustrates the proposed method using data on government expenditure for primary, secondary, and tertiary education, three strands (dimensions) of the education policy.

3.1. Data presentation

The data were extracted[1] from the "Education Statistics – All Indicators" database of the World Bank Databank[2]. Data from Austria, Finland, and Ireland have been selected for this application because they cover a long period of time, namely the 48 years between 1970 and 2017. However, some data for 1970, 1975, 1977, 1978, 1994 1997, and 1998 were missing and were therefore excluded from the calculations.

The data used show the annual amounts of government expenditure in constant USD dollars. The data are provided in Appendix 2.

The calculations were carried out using a calculator specially designed for this method, the "SSD Calculator" (Tchibozo, 2023b). The calculator is available to

[1] August 2023

[2] https://databank.worldbank.org/

download from the web[3] for replication of analyses and subsequent use.

3.2. Calculations

Tables 3.1 and 3.2 below present the intermediate calculations and the final results.

Table 3.1
Intermediate calculations
Note – I: Primary Education; II: Secondary Education; III: Tertiary Education

	Austria			Finland			Ireland		
	I	II	III	I	II	III	I	II	III
Number of years for which data were entered	46	46	46	44	44	44	45	45	45
Trends in budget amounts									
Overall growth indices of budgets	2.1	2.9	8.0	2.1	2.7	8.6	6.3	5.2	14.5
Number of annual growth indices	45	45	45	43	43	43	44	44	44
Average growth indices of budgets	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

[3] https://gtsite.xyz/1/ssd-calculator/

	Austria			Finland			Ireland		
	I	II	III	I	II	III	I	II	III
	Degree of stability or instability in budget allocation								
Standard deviations of annual budget series	814	1916	2050	480	1667	1588	1413	1197	930
Averages of annual budget series	2755	6955	3568	2592	4181	2828	2140	2297	1441
Coefficients of variation of annual budget series	0.29	0.27	0.57	0.18	0.39	0.56	0.66	0.52	0.64
	Trends in budget allocation instability								
Overall growth indices of SSDs	0.74	17.9	0.51	0.02	0.52	3.09	9.55	3.52	13.1
Number of annual growth indices of SSDs	43	43	43	41	41	41	42	42	42
Average growth indices of SSDs	0.99	1.06	0.98	0.91	0.98	1.02	1.05	1.03	1.06

Table 3.2
Final results
Note – I: Primary Education; II: Secondary Education; III: Tertiary Education

	Austria			Finland			Ireland		
	I	II	III	I	II	III	I	II	III
Trends in budget amounts									
Logarithm of average growth index of budgets	0.01	0.02	0.04	0.01	0.02	0.05	0.04	0.03	0.06
Interpretation: * = Increasing budgets									
	*	*	*	*	*	*	*	*	*
Degree of stability or instability in budget allocation									
Coefficient of variation of the series of annual budgets	0.29	0.27	0.57	0.18	0.39	0.56	0.66	0.52	0.64
Interpretation: * = Low instability; ** = Moderate instability									
	*	*	**	*	*	**	**	**	**

	Austria			Finland			Ireland		
	I	II	III	I	II	III	I	II	III
	Trends in budget allocation instability								
Logarithm of the average growth index of the SSDs	-0.006	0.06	-0.01	-0.08	-0.01	0.02	0.05	0.03	0.06
	Interpretation: * = Increasing instability; ** = Decreasing instability								
	**	*	**	**	**	*	*	*	*

3.3. Comments

In this example, the calculations show that in each of the three countries, the education budgets have followed an upward trend on average in each of the three strands throughout the period. The increase was faster in higher education than in the other two strands. In Austria and Finland, budgets increased more rapidly in secondary education than in primary education.

However, the annual budget allocation did not follow the same stability pattern everywhere. The results can be read either in terms of comparisons between countries, or in terms of comparisons between education strands.

When comparing countries, two groups can be distinguished. On the one hand, Austria and Finland have experienced little instability in annual budget allocations in primary and secondary education. In both countries, instability has tended to decrease in primary education. In secondary education, instability increased in Austria and decreased in Finland. Instability was higher (mid-level) and of similar magnitude (coefficient of variation ≅ 0.56) in tertiary education in both countries, and tended to increase in Finland while decreasing in Austria.

The situation was quite different in Ireland, where the annual allocation instability was at mid-level in all three education strands, and on the increase in all strands throughout the period. The increase was faster in tertiary and primary education than in secondary education. The increasing trend seems to suggest that none of the three strands in this country has been guaranteed against annual funding instability over such a long period. This raises the question of the extent to which this instability was deliberate and questions the underlying rationale.

When comparing education strands, it turns out that tertiary education has undergone mid-level annual allocation instability in all three countries, and that this instability has increased in Finland and Ireland.

Also, the same data show that allocation instability in tertiary education occurred while tertiary education in these three countries was in very different positions to the other strands at the time. In Austria, tertiary education was 'privileged' compared to primary education since its average annual budget over the period exceeded that of primary education by a third. In Ireland, on the other hand, tertiary education had a lower priority than primary education, with an average annual budget one-third lower than that of primary education. In Finland, tertiary education was on an equal footing with primary education, with the average annual budgets of the two strands very close to each other.

It is unlikely that such long-lasting trends are simply due to chance.

This begs the question of the underlying reasons, and whether similar discrepancies may also have occurred (in these or other countries) between other education strands, e.g., general *vs* vocational education, or universities *vs* non-university higher education.

It would certainly be interesting and instructive to explore this issue further. But education policy was just one example here to illustrate the implementation of the method.

4. Conclusion

This book aims to launch a debate on the need, relevance, timeliness, and methods for analyzing the dynamics of resource allocation in long-term multidimensional public policies. As indicated in the introduction, the implementation of such policies will inevitably shape the coming decades. It is therefore essential to approach LTMDPs with the most comprehensive toolbox possible. This book argues that dynamics analysis is one of the tools to be taken into account.

The book proposes a method for specifying the dynamics of resource allocation in LTMDPs, as well as a calculation tool for operationalizing it. This paves the way for a growing number of standardized, comparable, systematic, and replicable analyses in this field.

The proposed method makes it possible to measure the exact characteristics of a given dynamic, without having to take the necessarily more approximate – and more complex – route of adjusting a function that would be supposed to represent this dynamic. Nor is the functional approach necessary since there is no need for forecasting in this matter. Given the preponderance of political considerations in the decisions that result in the stability or instability of budget allocation, it would be futile to attempt to forecast the future of allocation dynamics in any policy.

The proposed approach is flexible as it can be applied to a whole range of configurations for analyzing the dynamics of resource allocation in the context of LTMDPs. These include not only analyzing the dynamics in respective strands of a given LTMDP, but also, among others:

- Comparing the dynamics between several LTMDPs (each of them taken as a strand) within a country or at international level;
- Analyzing the specific allocation dynamics of each of the quantifiable resources used for policy development, such as, for example, funding differentiated by source (e.g., not only national but also local or international) or staffing levels, and compare the dynamics of the different types of resources;
- Comparing the dynamics of a given LTMDP between distinct historical periods for which data are available.

Measuring the scale and trend of stability or instability in resource allocation enables us to assess whether, and to what extent, the different strands of a policy may have been treated differently in terms of allocation stability, particularly in the case of marked instability. This then leads to further questions about the rationale and relevance of allocation decisions, and their implications, including for policy performance.

An important next step in this respect is to investigate how allocation dynamics can influence the outcomes of LTMDPs. This could be done, for example, by using the characteristics of the dynamics as independent variables in regression analyses of policy outcomes.

In addition, allocation dynamics invite discussion from different angles, including, in particular, how exactly resource allocation relates to policy uncertainty. Allocation dynamics should also be discussed from the perspectives of benchmarking, cross-country comparison, and economic convergence.

Finally, a better understanding of the dynamics of resource allocation and its role could certainly help complete the toolbox to inform decision-making in the area of budgetary arbitration.

At this stage, however, this is still a work in progress. As previously said, this book isn't but an introductory attempt. The approach proposed here will certainly be improved by future research.

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Case in which L_{SSD} cannot be calculated

The logarithm of the average growth index of the secondary standard deviations, L_{SSD}, cannot be calculated if the average growth index of the secondary standard deviations (*SSDs*) is equal to zero. Such is the case if at least one *SSD* is equal to zero, i.e., if at least for one *SSD*, the sum of the squared differences from the mean is equal to zero. This is only possible if, in this *SSD*, each squared difference from the mean is equal to zero, which in turn implies that for at least two consecutive sub-periods, the primary standard deviations (*PSDs*) of the two sub-periods are equal. For example, expression (1.5) in Chapter 1 says that:

$$ssd_3^m = \sqrt{\frac{\left[psd_2^m - \left(\frac{psd_2^m + psd_3^m}{2}\right)\right]^2 + \left[psd_3^m - \left(\frac{psd_2^m + psd_3^m}{2}\right)\right]^2}{2}}$$

which means that:

$$ssd_3^m = 0 \; if \begin{cases} \left[psd_2^m - \left(\frac{psd_2^m + psd_3^m}{2}\right)\right]^2 = 0 \\ and \\ \left[psd_3^m - \left(\frac{psd_2^m + psd_3^m}{2}\right)\right]^2 = 0 \end{cases} \qquad \text{(A.1)}$$

which in turn equates to:

$$psd_2^m = psd_3^m \tag{A.2}$$

So, let's now consider two consecutive sub-periods: sub-period 1, delimited by budget y_1 and budget y_2; and sub-period 2, delimited by budget y_2 and budget y_3.

The *PSDs* of the two sub-periods are equal if:

$$\left[y_1 - \left(\frac{y_1+y_2}{2}\right)\right]^2 + \left[y_2 - \left(\frac{y_1+y_2}{2}\right)\right]^2 = \left[y_2 - \left(\frac{y_2+y_3}{2}\right)\right]^2 + \left[y_3 - \left(\frac{y_2+y_3}{2}\right)\right]^2 \tag{A.3}$$

which implies:

$$y_1^2 - 2y_1y_2 = y_3^2 - 2y_2y_3 \quad \text{A.4)}$$

which in turn implies:

$$2y_2y_3 - 2y_1y_2 = y_3^2 - y_1^2 \tag{A.5}$$

$$\Rightarrow 2y_2(y_3 - y_1) = y_3^2 - y_1^2 \tag{A.6}$$

$$\Rightarrow 2y_2 = \frac{y_3^2 - y_1^2}{y_3 - y_1} \tag{A.7}$$

$$\Rightarrow 2y_2 = \frac{(y_3 + y_1)(y_3 - y_1)}{y_3 - y_1} \tag{A.8}$$

which finally leads to:

$$y_2 = \frac{y_1 + y_3}{2} \tag{A.9}$$

and finally shows that the logarithm of the average growth index of the secondary standard deviations cannot be calculated if for at least one pair of consecutive sub-periods, 1 (from budget y_1 to budget y_2) and 2 (from budget y_2 to budget y_3), the intermediary budget y_2 is equal to the average of the first and last budgets.

APPENDIX 2

Government expenditure on primary, secondary, and tertiary education
Austria, Finland, Ireland — 1970–2017 — Constant US$ (millions)

Source: World Bank Databank, "Education Statistics – All Indicators" database.

Table A1. Austria			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST.1.FSGOV	UIS.X.USCONST.2T3.FSGOV	UIS.X.USCONST.5T8.FSGOV
1970	1733,355	2992,518	884,2274
1971	1833,472	3303,23	961,0201
1972	1895,11	3605,928	1080,017
1973	1823,406	4036,915	1140,151
1974	1951,542	4252,023	1257,321
1975	2049,649	4670,539	1421,062
1976	1853,644	5055,011	1513,923
1977	1845,536	5071,855	1419,363
1978	1866,975	5348,026	1441,087

Table A1. Austria			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X.USCONST. 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
1979	1847,842	5575,079	1494,457
1980	1795,955	5665,545	1509,686
1981	1715,198	5673,085	1544,966
1982	1775,334	5685,639	1647,908
1983	1699,329	5773,302	1759,075
1984	1939,54	5495,669	1952,795
1985	2009,395	5699,954	2030,436
1986	2070,71	5913,095	2417,536
1987	2126,029	5987,977	2392,341
1988	2146,517	5894,947	2467,665
1989	2178,901	5882,88	2499,89
1990	2263,444	6107,554	2540,592
1991	2420,23	6389,319	2832,115
1992	2614,979	6782,466	2954,302
1993	2584,244	6612,252	2881,464
1994			
1995	3289,922	7157,219	3282,251
1996	3164,598	7316,236	3186,269
1997			

Table A1. Austria			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X.USCONST. 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
1998	3603,76	8184,236	4872,568
1999	3733,481	8635,979	5044,13
2000	3586,445	8268,581	4553,598
2001	3612,534	8315,34	4348,691
2002	3666,58	8466,201	4179,946
2003	3579,874	8882,779	4269,002
2004	3494,617	8718,601	4816,907
2005	3545,605	8574,5	5092,512
2006	3570,055	8955,503	5222,249
2007	3540,958	9089,882	5450,562
2008	3635,588	9430,972	5542,03
2009	3720,627	9977,298	5592,652
2010	3705,57	9594,378	5994,227
2011	3733,223	9906,197	5864,859
2012	3337,703	8880,957	7176,01
2013	3556,324	8988,966	7054,426
2014	3514,403	8704,496	7012,318
2015	3615,08	8701,138	7120,565
2016	3716,361	8871,801	7273,409

Table A1. Austria			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X.USCONST. 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
2017	3789,01	8845,309	7142,357

Table A2. Finland			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X. USCONST 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
1970	1604,052	2207,109	487,1587
1971	1694,043	2153,657	490,1627
1972	2048,128	1725,562	575,328
1973	2250,576	1832,236	663,1595
1974	2067,532	1566,915	673,3668
1975	2389,427	1730,403	783,7839
1976	2611,997	1671,768	818,9987
1977			
1978			
1979	1895,838	2274,341	1132,056
1980	1933,731	2498,589	1195,322
1981	1951,513	2532,729	1213,18
1982	1885,618	2704,615	1227,663
1983	1985,822	2863,982	1243,014
1984	1980,637	2844,356	1264,49
1985	2211,37	3112,278	1435,423
1986	2395,389	3223,414	1413,709
1987	2518,654	3303,212	1594,826
1988	2525,33	3346,435	1744,019

Table A2. Finland			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X. USCONST 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
1989	2551,385	3525,743	1922,878
1990	2636,386	3688,987	2172,377
1991	2632,688	3903,701	2703,527
1992	2582,658	3759,851	2848,495
1993	2774,097	3872,094	3061,445
1994	2646,902	3919,334	2657,218
1995	2641,34	3891,643	3037,327
1996	2782,626	4095,362	3161,278
1997			
1998			
1999	2373,077	4412,075	3781,988
2000	2461,411	4460,265	3913,763
2001	2610,416	4834,88	3976,654
2002	2732,03	5129,711	4107,667
2003	2856,86	5427,108	4236,274
2004	2936,939	5634,457	4421,668
2005	2866,779	5790,83	4392,753
2006	2914,645	5964,062	4473,959
2007	2901,087	6061,169	4465,507

Table A2. Finland			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X. USCONST 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
2008	3004,544	6313,27	4573,729
2009	2973,817	6388,341	4770,169
2010	3107,714	6626,631	4971,781
2011	3174,33	6664,8	5079,796
2012	3191,501	6583,512	4955,168
2013	3189,447	6472,823	4804,357
2014	3253,015	6374,927	4750,388
2015	3429,695	6347,761	4522,805
2016	3477,496	6264,16	4499,977
2017	3422,288	5983,503	4222,717

Table A3. Ireland			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X.USCONST. 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
1970			
1971	636,8859	698,6306	223,9963
1972	650,4999	711,3846	277,1342
1973	644,7227	755,4077	272,8273
1974	691,3859	796,0098	294,9758
1975			
1976	751,7216	743,9863	370,5035
1977	918,6466	990,8042	507,6304
1978	1018,023	1134,595	553,7357
1979	1079,203	1227,472	594,6018
1980	1120,71	1279,002	607,0457
1981	1256,008	1426,037	672,6866
1982	1219,703	1396,335	622,8696
1983	933,5511	1384,57	600,2515
1984	984,2192	1390,383	563,069
1985	1003,79	1396,423	611,4684
1986	1007,729	1398,967	642,9783
1987	1089,228	1528,795	745,2917
1988	1040,02	1474,009	705,299

Table A3. Ireland			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X.USCONST. 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
1989	1047,156	1476,617	706,676
1990	1089,677	1511,229	825,8437
1991	1154,709	1610,484	865,4782
1992	1225,752	1698,343	976,6507
1993	1237,363	1842,128	1032,401
1994	1283,927	2022,932	1132,145
1995	1279,93	2110,676	1180,916
1996	1294,176	2175,065	1315,43
1997			
1998	1895,144	2176,855	1476,847
1999	1953,004	2257,714	1676,925
2000	2083,237	2305,143	2044,977
2001	2246,824	2420,679	2009,085
2002	2431,525	2571,711	2066,233
2003	2696,337	2785,813	1960,624
2004	3009,993	3172,286	2107,112
2005	3219,628	3333,235	2229,69
2006	3423,109	3515,951	2420,13
2007	3869,132	3789,444	2576,759

Table A3. Ireland			
	Primary education	Secondary Education	Tertiary Education
	UIS.X.USCONST. 1.FSGOV	UIS.X.USCONST. 2T3.FSGOV	UIS.X.USCONST. 5T8.FSGOV
2008	4378,766	4244,679	2832,446
2009	4657,406	4382,876	3093,294
2010	4613,254	4413,279	2900,33
2011	4538,68	4322,274	2760,921
2012	4624,837	4189,838	2681,496
2013	4260,706	3934,897	2528,464
2014	4253,288	3893,383	2434,047
2015	4148,263	3746,384	2626,65
2016	4308,361	4103,876	2260,77
2017	4073,39	3636,116	3266,417

A theory on specifying resource allocation dynamics in long-term multidimensional public policies

Guy Tchibozo

This book defines a notion of long-term multidimensional public policy, and focuses on the question of how to specify the stability or instability in resource allocation under such policies. The book proposes a method for characterizing the dynamics of resource allocation, as well as a calculation tool for operationalizing the proposed method. The book highlights the issues at stake in this field and underlines the research potential it holds.

Keywords: *Budget allocation – Budgetary arbitration – Budgetary process – Instability analysis –Policy analysis – Policy performance – Policy uncertainty – Political science – Public finance – Public administration – Secondary standard deviations*

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ISBN 978-952-390-600-6

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