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## Computing currency invariant indices with an application to minimum variance currency baskets

Nikolai V. Hovanov<sup>a</sup>, James W. Kolari<sup>b,\*</sup>, Mikhail V. Sokolov<sup>c</sup>

<sup>a</sup>Department of Economics, St. Petersburg State University, St. Petersburg, Russia

<sup>b</sup>Finance Department, Texas A&M University, TAMU-4218, College Station, TX 77843, USA

<sup>c</sup>A.V.K. Investment Company, St. Petersburg, Russia

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### Abstract

This paper provides an exact and computable *invariant currency value index (ICVI)* which is independent of base currency choice. Thus, given a fixed set of currencies, the index of a currency will have the same value, regardless of base currency choice. This currency index can be used as an indicator to assess movements of an individual currency's value in world currency markets. The methodological and mathematical reasoning behind *ICVI* is formulated in terms of a *simple exchange model (SIMEX)*.

To demonstrate one possible application we employ *ICVI* to construct a currency basket of minimum variance. Utilizing a quadratic optimization framework, we compute optimal weights for currencies and construct a *stable aggregate currency (SAC)*. Comparative empirical analyses of a five-currency *SAC* and the IMF's Special Drawing Rights (*SDR*) demonstrates that the *SAC* has lower volatility and lower correlations with its components than the *SDR*. In a similar way it is shown that a three-currency *SAC* has a smaller variance than the world money basket proposed by R. Mundell. Numerous academic and business implications are possible for further study with the use of the indices *ICVI* and *SAC*.

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\* Corresponding author. Tel.: +1-409-845-4803; fax: +1-409-845-3884.

E-mail address: [j-kolari@tamu.edu](mailto:j-kolari@tamu.edu) (J.W. Kolari).

## 1. Introduction

It is common practice in international economics and finance to denominate multiple currencies in terms of a base currency or numeraire. One problem with this multi-currency convention is that, depending on the base currency chosen, the resulting time series can dramatically change their dynamics due to fluctuations in currency values over time. For example, the relationship between the yen and pound sterling will be different if the dollar is used as the numeraire from the case when the euro is used as numeraire.

This paper provides an exact and computable *invariant currency value index (ICVI)* which is independent of base currency choice. Thus, given a fixed set of currencies, the index of a currency will have the same value, regardless of base currency choice. As such, *ICVIs* for the dollar, euro, and yen are independent of a chosen base currency. The conception of the invariant index of a currency's value in exchange is based on a *simple exchange model (SIMEX)*, which describes direct pair-wise exchanges of goods (commodities, services, currencies, etc.). We show that *ICVIs* could be used to better understand the valuation of currencies and other assets in a global context in which multiple currency participants exist. In this respect they could be used to gain insight into currency value questions such as: Did the U.S. dollar go up or down in world currency markets? To our knowledge, no other work has been published on this potentially valuable multi-currency index. *ICVIs* could be applied to a variety of empirical problems in international economics and finance.

To demonstrate one possible application we employ our *ICVI* to solve for a minimum variance currency basket. Throughout history, economists have sought a stable numeraire (or benchmark commodity) for the purpose of international trade and finance. Utilizing a variance minimization framework, we compute optimal weights for five hard currencies and construct a *stable aggregate currency (SAC)*. Comparative empirical analysis of *SAC* and the IMF's Special Drawing Rights (*SDR*) for the period 1981–1998 demonstrates the low volatility and low correlations with its components of this stable aggregate currency. We therefore conclude that the *SAC* could be used to harden the *SDR*.

Following recent work by Nobel Laureate Robert Mundell, further analyses consider the problem of constructing a stable world currency. In Mundell's words, "A few economists have recently recognized the merits of and need for a world currency. Whether that can be achieved in the near future will depend on politics as well as economics. But it is, nevertheless, a project that would restore a needed coherence to the international monetary system." (Mundell and Friedman, 2001, p. 27). A comparative analysis of Mundell's recommended world currency basket to our minimum variance currency basket constructed from the same currencies confirms the low volatility and correlations with its components of *SAC*. We conclude that the simplicity of *SAC* could be used to develop a world money that would be easy for businesses in the financial services industry to implement.

Our invariant currency value index and stable aggregate currency have major implications to the construction of index numbers for contract settlement. Shiller (1993) has argued that the development of macro markets is dependent on the availability of

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