



Are shocks to the terms of trade shocks to productivity? ☆

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ABSTRACT

International trade is frequently thought of as a production technology in which the inputs are exports and the outputs are imports. Exports are transformed into imports at the rate of the price of exports relative to the price of imports: the reciprocal of the terms of trade. Cast this way, a change in the terms of trade acts as a productivity shock. Or does it? In this paper, we show that this line of reasoning cannot work in standard models. Starting with a simple model and then generalizing, we show that changes in the terms of trade have no first-order effect on productivity when output is measured as chain-weighted real GDP. The terms of trade do affect real income and consumption in a country, and we show how measures of real income change with the terms of trade at business cycle frequencies and during financial crises.

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1. Introduction

The terms of trade—the price of imports relative to the price of exports—vary greatly over time and country. This variation makes the terms of trade a natural candidate for explaining country performance. Intuitively, we can think about foreign trade as a production technology: a country's exports are the inputs to the technology, and these inputs are turned into outputs that are recorded as a country's imports. Exports are transformed into imports at the rate that is the ratio of the price of exports to the price of imports, which is just the reciprocal of the terms of trade. Viewed in this way, an increase in the terms of trade acts much like a technology shock: the same amount of exports now produces a smaller amount of imports.

In this paper, we show that standard models do not support this line of reasoning when we measure technology shocks using total factor productivity (TFP) where output is measured using real gross domestic product (GDP). The problem lies in the construction of real GDP. The effect of a shock to the terms of trade on real GDP is not the same as the effect of a productivity shock and is dependent upon the method used to construct real GDP. When real GDP is constructed using the chain-weighting method specified in the United Nations System of National Accounts, terms of trade shocks have no first-order effects if inputs of factors are constant. When real GDP is constructed using fixed base year prices, the effect of

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a terms of trade shock is ambiguous: in some cases a deterioration of the terms of trade can even increase real GDP! In this paper, we bring this accounting to bear on the relation between the terms of trade and productivity. As productivity is computed using real GDP as the measure of output, the terms of trade cannot have a direct effect on a country's TFP. If factors of production can vary, changes in the terms of trade can cause real GDP to vary, but, even so, there is no first-order effect on TFP. An increase in the terms of trade lowers the purchasing power of the country, which can be painful in terms of consumption and welfare, but does not impact TFP.

The relation between changes in the terms of trade and changes in real GDP is well understood by economists interested in index numbers and national income accounting. Diewert and Morrison (1986) and Kohli (1983, 2004), for example, explain that changes in the terms of trade are considered a price phenomenon, not a real phenomenon, in the construction of real GDP. These researchers also propose other measures of real income that treat terms of trade shocks as if they were technology shocks. We discuss these measures later in the paper.

This paper explores the relation between TFP shocks and terms of trade shocks in models and contrasts this relation with the relation in the data. In particular, we focus on TFP measured using real GDP, rather than on real GDP itself. When we examine data for the United States and Mexico over the past several decades, we see that sharp deteriorations in the terms of trade are accompanied by drops in real GDP and that most of these drops in real GDP are driven by drops in TFP, not drops in factor inputs. Since standard models cannot account for these drops in TFP, our paper identifies a puzzle and poses a challenge for researchers working with open economy models: If we think that terms of trade shocks cause TFP fluctuations, we need to develop a new mechanism for generating this causal relation and build it into our models. Otherwise, we need to come up with some other reasoning to explain why sharp deteriorations in the terms of trade and drops in TFP are highly correlated in the data, especially during financial crises in developing countries like Mexico.

The empirical literature on growth is replete with examples of the association of the terms of trade with output growth and with productivity growth. Easterly et al. (1993) study a large panel of countries to uncover the sources of long-run growth and aggregate volatility. They conclude that “shocks, especially to the terms of trade, play a large role in explaining variance in growth.” In setting out a framework for studying developing country growth, Easterly et al. (2001) find that volatility in the terms of trade is more strongly correlated with volatility in output than are the standard deviations of many of the usual suspects: money growth, fiscal balance, and capital flows, to name a few. Becker and Mauro (2005) use a large panel of countries to study how output drops are related to various external shocks and, using the likelihood of the shock and the associated output drop, compute the cost of the different shocks. They find that the costliest shocks, particularly for developing countries, are terms of trade shocks. The idea underlying many of these conclusions is succinctly summarized by Easterly et al. (2001), who write, “For small *open* economies, adverse terms of trade shocks can have much the same effect as negative technology shocks, and this is one of the important differences between macroeconomics in these economies and that which underlies some of the traditional closed economy models.”

In line with the above reasoning, we show that, in standard models, a shock to the terms of trade has an effect on consumption and welfare that is similar to a TFP shock. The analogy between the terms of trade and productivity breaks down when we calculate their effects on real GDP and on TFP. When real GDP is measured at base period prices and domestic factors of production are held fixed, the effect of a terms of trade shock on real GDP is determined by the current terms of trade relative to the base period terms of trade. If the current import price is the same as the base period price, then the shock has no effect. If the current price is higher than the base period price, the effect is negative, and, conversely, if the current price is lower, the effect is positive. With base period price weighting, a change in the terms of trade can have a first-order effect on GDP, but this result follows from an artifact of the deflation method and not from an underlying structural relationship. When we consider real GDP calculated as a chain-weighted index – as is now the standard for many countries – these artifacts disappear. Changes in the terms of trade do not have a first-order impact on real GDP, and TFP remains unchanged.

We expand the simple examples to show that our results easily generalize to richer environments. We show that a shock to the terms of trade can affect the supply of productive factors like labor and that the effects of these shocks, as in the simple examples, also have an ambiguous impact on real GDP at base period prices. With chain-weighted GDP the ambiguity disappears and the effect on GDP comes only through factor supplies, implying that TFP is not affected by the terms of trade. A third set of results shows how the effect of a terms of trade shock on real GDP and consumption varies with the elasticity of substitution between the domestic factors and the imported input. As the elasticity of substitution decreases, changes in the terms of trade have larger impacts on consumption but smaller impacts on real GDP. When the production function uses domestic and imported inputs in fixed proportions, changes in the terms of trade have a large impact on consumption, but no impact on real GDP.

If the terms of trade do not have a clear effect on measures of real GDP and TFP, where are their effects visible? In national accounting measures, the terms of trade affect gross domestic income (GDI). In a closed economy, real GDI and real GDP are the same, but in an open economy they are not. In Section 7, we discuss alternative measures of real income, including the concept of command basis GDP used by the US Bureau of Economic Analysis. These measures do respond to changes in the terms of trade and reflect how the purchasing power of an economy changes as foreign prices change.

The problems highlighted in this paper are part of a much larger issue faced by quantitative researchers. Developing good intuition is paramount in understanding how models work, and constructing analogies, such as the one between the terms of trade and productivity, can be very helpful in developing intuition. When evaluating the quantitative properties of a model, however, the statistics taken from the model must be constructed in the same way as they are in the data. As we

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