Economic Modelling 35 (2013) 689–700

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

The cost of adjustment: On comovement between the trade balance and the terms of trade

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ARTICLE INFO

Article history:
Accepted 29 August 2013

JEL classification:
E32
F41
G15

Keywords:
Capital adjustment costs
Investment adjustment costs
S-curve
International business cycles

ABSTRACT

The S-shaped cross-correlation function between the trade balance and the terms of trade has been documented for several countries and time frames. The ability of two-country, two-good business cycle models to reproduce this regularity hinges on the dynamics of capital formation. We consider the consequences of modeling the adjustment costs for comovement in the trade balance and the terms of trade. Both complete and incomplete market models with capital adjustment costs à la Hayashi (1982) deliver the S-curve seen in the data while the model with investment adjustment costs à la Christiano et al. (2005) does not.

1. Introduction

> "One of the central questions of international economics concerns the relation between the trade balance and the terms of trade: what features of an economy determine whether an increase in the relative price of imports is associated with improvement or deterioration in the balance of trade?"
>
> [Backus, 1993, p. 375]

This paper attempts to answer Backus's question by focusing on a single class of frictions commonly used in open economy models. We assess the consequences of modeling adjustment costs to capital accumulation for comovements in the trade balance and the terms of trade. We restrict our attention to two types of functions. Investment adjustment costs (IAC), popularized by Christiano et al. (2005), punish changes in the level of investment. Capital adjustment costs (CAC), described by Hayashi (1982), penalize changes in the capital stock. Most two-country models rely on adjustment costs to capital formation to prevent excessive volatility of investment. This volatility is a consequence of perfect risk sharing. Hence, the benchmark we choose is a two-country, two-good business cycle model with complete markets.

Since the seminal work of Backus et al. (1992, 1994, 1995) (henceforth BKK), adjustment costs to capital formation have been used extensively in the context of international business cycle models. BKK use a "time-to-build" structure, as in Kydland and Prescott (1982), to dampen the volatility of cross-border investment flows in response to location-specific productivity shocks. However, since the publication of Baxter and Crucini (1995), it has been more common to use Hayashi's (1982) convex capital adjustment costs (e.g. Baxter and Farr, 2005; Yakhin, 2007). Alternative specifications of the capital adjustment cost friction have also been used by Kollmann (1996) and Raffo (2008). Several more recent papers rely on investment adjustment costs to match observed investment volatility. For instance, Enders and Müller (2009) use IAC in an environment with exogenously incomplete markets, while Thoenissen (2011) does so in the complete market setting. Our main result is that a model featuring capital adjustment costs is consistent with the empirical "S-curved" pattern of cross-correlations between the trade balance and the terms of trade, first observed by Backus et al. (1994), while a model with investment adjustment costs is not. The predictions of the model with capital adjustment costs are robust to the degree of persistence and spillovers of the forcing process, whereas those of the model with investment adjustment costs are not. The two specifications have surprisingly similar predictions for the comovements of quantity aggregates.

To understand the intuition for our result, consider the dynamic responses to a positive productivity shock in the home country. Since each country specializes in the production of a single traded good, a boost to productivity at home results in a relative scarcity of the

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http://dx.doi.org/10.1016/j.econmod.2013.08.027

foreign-produced good. On impact, the price of imports rises relative to the price of exports. As the productivity differences diminish, the terms of trade slowly decline towards their steady-state value. This dynamic response does not depend on the presence or specification of adjustment costs to capital formation. Adjustment costs affect the dynamics of the terms of trade and the trade balance through their effect on the latter.

Under capital adjustment costs, a home productivity shock causes domestic investment to jump on impact. This induces domestic absorption to rise by more than domestic output, causing an immediate deterioration of the trade balance. Net exports then increase as the effect of the productivity shock on investment dissipates. Meanwhile, the terms of trade rise on impact before starting a gradual decline. This implies a negative but increasing correlation between the terms of trade and leads of the trade balance. The cross-correlation function mimics the S-curve pattern seen in the data.

Under investment adjustment costs, investment displays a hump-shaped response to a positive local productivity shock. Domestic absorption inherits from investment its hump-shaped profile. The trade balance in the home country exhibits an inverted hump-shaped profile in response to the productivity shock. As a result, the correlation between the terms of trade and leads of the trade balance declines. This behavior is inconsistent with the S-curve pattern.

While CAC dominate IAC in accounting for the S-curve in our benchmark model, it is worth asking whether this result is specific to our benchmark or a more general feature. We find that our findings are robust to alternative specifications. First, we vary the assumption of complete markets, by restricting financial markets to a single risk-free, one period bond, along the lines of Baxter and Crucini (1995) and Heathcote and Perri (2002). Restricting markets does little to improve the cross-country co-movements of quantity aggregates. As in our benchmark case, with capital adjustment costs we can reproduce the S-curve regularity, while with investment adjustment costs we cannot.

In a second extension, we retain complete markets and develop the environment along the lines of Dmitriev and Roberts (2012) to allow time inseparability of preferences and an arbitrarily small wealth effect on labor supply. In this case, the model resolves the 'international comovement puzzle'. That is, unlike our benchmark and the bond economy, it reproduces the observed positive cross-correlations of investment and employment. Again, capital adjustment costs are consistent with the empirical S-curved pattern, while investment adjustment costs are inconsistent.

Our work contributes to the expanding body of literature that examines the effect of adjustment costs on capital formation. The first branch of this literature estimates the magnitude of adjustment cost using aggregate or industry-wide data. Recent contributions include Hall (2004) and Groth and Khan (2010). The former estimates the magnitude of capital adjustment costs at the industry level, while the latter do the exercise for investment adjustment costs.

A second branch examines the relative performance of CAC and IAC within major classes of DSGE models. For instance, Christiano et al. (2005) consider a closed economy New Keynesian model. They show that IAC outperform CAC in accounting for hump-shaped investment responses to monetary shocks. Beaubrun-Diant and Tripier (2005) consider a horse-race between IAC and CAC in a closed economy real business cycle model. They conclude that IAC better account for business cycle and asset pricing phenomena than CAC. In contrast, Basu and Thoenissen (2011) find that the observed inverse relationship between the price of investment goods and the investment rate in an international business cycle model driven by TFP shocks is invariant to whether IAC or CAC are used. Our paper contributes to this second branch of the literature. It extends the discussion of the merits of IAC and CAC to a broader consideration of the ability of two-country models driven by productivity shocks to match the data. We conclude that capital adjustment costs do a better job than investment adjustment costs in accounting for international business cycle facts.

Most business cycle models use some form of adjustment costs to moderate the volatility of investment. Yet, our results show that the precise form of this friction influences a model's ability to generate the observed features of the data, such as the correlation between the terms of trade and the trade balance. This is important from a modeling perspective for two reasons: First, both capital and investment adjustment costs are commonly used in the open economy macroeconomics literature.[1] Second, the calibration approach employed by most international business cycle models requires that investment volatility predicted by the model be in line with the data. Christiano et al. (2005) first proposed utilizing investment adjustment costs to reproduce the hump-shaped response of investments to shocks in a closed economy model. The use of investment adjustment costs has since become increasingly popular in both closed and open economy applications. Our results, however, suggest that this specification of adjustment costs should be used with caution in an open economy setting.

The rest of the paper is organized as follows. The next section documents the empirical relationship between the trade balance and the terms of trade. Section 3 describes the model economy. Section 4 reports our quantitative results and discusses how different types of adjustment costs affect the model's ability to reproduce the S-curve. It also presents two extensions. Section 5 offers some concluding remarks.

2. Comovement between the trade balance and the terms of trade: The S-curve

We start by reviewing the relationship between the trade balance (*NX*) and the terms of trade (*TOT*) for recent data. Fig. 1 plots cross-correlation functions for $NX(t+k)$ and $TOT(t)$ for k ranging from -8 to 8 quarters. Our samples cover the US, the composite of 15 European countries (EU-15), and the four largest European economies individually. With the exception of the UK, the comovement between the trade balance and the terms of trade exhibits the S-shaped pattern described by BKK. This conclusion holds for two sample lengths.[2]

We would like to emphasize two properties common to the cross-correlation functions for all economies and samples reported:

i) The correlation between $NX(t+k)$ and $TOT(t)$ is negative for $k=0$, and for several first positive lags k;
ii) The correlation between $NX(t+k)$ and $TOT(t)$ is increasing for the few first positive lags k.

In the rest of the paper, we will rationalize these properties by referring to the transmission mechanism of technology shocks discussed by BKK. We will show that while capital adjustment costs are consistent with the S-curve, investment adjustment costs are not.

We are not the first to report the S-shaped cross-correlations between the trade balance and the terms of trade. In addition to BKK, who coined the term "S-curve", the related literature includes Senhadji (1998) who documents an S-shaped relation between leads and lags of the two variables for emerging economies. More recently, Bahmani-Oskooee and Ratha (2007) describe this regularity between the US and its trading partners. Enders and Müller (2009) document both conditional and unconditional S-curves for recent US data.

3. The model economy

The economic environment we consider consists of two countries. The same parameters describe technology and preferences in both countries. Each country $j=1,2$ is populated by a continuum of identical

[1] Recent examples of the models that use CAC include Baxter and Farr (2005), Boileau and Normandin (2008), Devereux and Hnatkovska (2011), Gourio et al. (2013), Johri et al. (2011), and Raffo (2008). Models that rely on IAC include Justiniano et al. (2010, 2011), Mandelman et al. (2011), and Rabanal and Tuesta (2010).

[2] BKK showed that the pattern of cross-correlations between *TOT* and *NX* might depend on the sampling period. Therefore, we consider a sample covering 1984:1–2010:2 and its subsample covering 1991:1–2010:2. Our subsample starts at the end of BKK's sample.