CAHIER D'ÉTUDES
WORKING PAPER

N° 83

NEWS SHOCKS, REAL EXCHANGE RATES AND INTERNATIONAL CO-MOVEMENTS

Kyriacos LAMBRIAS

JULY 2013

BANQUE CENTRALE DU LUXEMBOURG
EUROSYSTÈME

News Shocks, Real Exchange Rates and International Co-Movements

*Kyriacos Lambrias**

July 24, 2013

Disclaimer: This paper should not be reported as representing the views of the Banque Centrale du Luxembourg (BCL) or the Eurosystem. The views expressed are those of the author and may not be shared by other research staff or policymakers in the BCL or the Eurosystem.

*Central Bank of Luxembourg, 2 Boulevard Royal, L-2983, Luxembourg. Email: kyriacos.lambrias@bcl.lu. I thank Patrick Fève, Martial Dupaigne, Christian Hellwig, Franck Portier, Evi Pappa, Roberto Pancrazi, Gilles Saint-Paul, Jidoud Ahmat, Eric Mengus, Samuele Centorrino, Fabrice Collard, Paolo Guarda, Olivier Pierrard, Luca Marchiori, participants at the EABCN meeting on "Global Spillovers and Economic Cycles" at Banque de France in May 2013 and seminar participants in Luxembourg and Toulouse for useful comments and discussions. All remaining errors and omissions are mine.

Abstract

We propose a fully flexible, complete-market model of the international business cycle that is consistent with two major empirical facts: positive cross-country co-movement of economic aggregates and a negative correlation between the real exchange rate and relative consumption (the Backus-Smith puzzle). The model features non-tradable goods, zero wealth effects on labour supply, imperfect substitutability of capital across sectors and variable capacity utilisation. The latter can generate strong Balassa-Samuelson effects that drive a low consumption-real exchange rate correlation. Cyclical movements across countries are also positively correlated. The novelty of our paper is to introduce changes in expectations (news-shocks) as an explanation to the Backus-Smith puzzle through the wealth effects of future changes in income, while being consistent with expectations-driven economic expansions.

Keywords: News-Driven Cycles, Backus-Smith Puzzle, Real-Exchange Rates
JEL Classification: F41, F44

Contents

Resumé non-technique

La théorie du cycle économique réel (en anglais "real business cycle" ou RBC) prend ses origines dans les travaux de Kydland et Prescott (1982); deux chercheurs qui ont gagné le prix Nobel d'économie en 2004. Ces auteurs sont parmi les premiers à fournir une explication du cycle économique dans le cadre d'un modèle d'équilibre général qui est uniquement perturbé par des chocs sur la productivité totale des facteurs. La théorie de l'équilibre général est caractérisée par trois piliers: (i) les ménages maximisent leur utilité, (ii) les entreprises maximisent leurs profits et (iii) tous les marchés sont en équilibre. Kydland et Prescott ont développé l'équilibre général dans un cadre dynamique: tous les agents prennent des décisions en tenant compte non seulement de l'état actuel de l'économie mais également de son état futur, anticipé à partir des actions prises aujourd'hui.

Quelques dix ans plus tard, Backus, Kehoe et Kydland (1992, 1994) ont ajouté une dimension internationale à cette famille de modèles. Bien que le modèle RBC s'adapte à la structure d'une économie fermée, ces auteurs ont démontré que le modèle RBC peine à expliquer les fluctuations conjoncturelles internationales. Selon les données, les mouvements des agrégats économiques (production, consommation, investissement et emploi) sont corrélés positivement à travers les pays, tandis que ces corrélations sont négatives dans le modèle RBC à deux pays. De plus, dans les données, la corrélation est négative entre le taux de change réel et la consommation relative (entre deux pays), tandis que dans les modèles RBC cette corrélation est positive. Ce dernier problème, connu sous le nom d' "énigme de Backus-Smith" ou "Backus-Smith puzzle", constitue l'un des plus grands défis de la théorie internationale du cycle économique. Plusieurs études ont tenté de résoudre ces deux problèmes, avec quelque succès pour le premier (corrélations positives entre pays) mais moins pour le deuxième (Backus-Smith puzzle).

Dans ce Cahier d'Études nous proposons un modèle RBC à deux pays qui est cohérent avec les corrélations observées dans les données. Plus précisément, notre modèle propose une solution au "Backus-Smith puzzle" par l'introduction de chocs "anticipés". Selon la théorie classique du cycle réel, les chocs à la productivité totale des facteurs sont complètement imprévisibles. En réalité, il est bien connu que les nouvelles technologies nécessitent du temps avant de se propager à l'ensemble de l'économie. Il est donc possible de prévoir l'impact futur des innovations technologiques même avant qu'elles ne soient commercialisées. Dans notre modèle les chocs technologiques sont parfaitement connus une période à l'avance, ce qui affecte les anticipations des agents économiques, sans pour autant changer le niveau actuel de la productivité. Il en résulte un effet de revenu qui ressemble à un choc de demande, augmentant les prix dans le pays concerné et modifiant ainsi le taux de change réel. Ceci permet au modèle de générer une corrélation négative entre le taux de change réel et la consommation relative, ce qui est cohérent avec les données. De plus, le modèle génère des corrélations positives entre pays pour les agrégats économiques (production, consommation, investissement et emploi). En conclusion, l'introduction de chocs "anticipés" permet d'améliorer la performance de notre modèle par rapport aux données, sans pour autant sacrifier les autres avancées obtenues par la littérature récente.

Les résultats empiriques confirment que les chocs liés à une hausse des revenus futurs conduisent à des expansions économiques. Une contribution majeure de notre papier est d'établir les fondements théoriques pour une telle expansion économique généralisée suite à un choc anticipé, tout en générant des mouvements des prix relatifs en ligne avec ceux observés dans les données.

1 Introduction

International cyclical fluctuations exhibit two distinctive features. First, macroeconomic aggregates like output, consumption, investment and hours worked are positively correlated across countries. Second, the correlation between the real exchange rate and relative consumption is low or negative, implying that consumption is higher where it is more expensive. Standard macroeconomic theory has difficulty reconciling these facts. The frictionless, complete markets model of Backus, Kehoe and Kydland (1992, 1994, henceforth BKK) suggests that following a productivity shock resources move to the country that is the most productive, implying a negative correlation of investment across countries. Moreover, wealth effects among the residents of the country whose productivity did not improve should increase leisure, hence hours worked should also move in opposite directions. Further, perfect risk sharing in the BKK world instructs that the international transmission of productivity shocks is positive, working via a depreciation in the real exchange rate at home and an improvement in the terms of trade abroad. Efficiency and home-bias imply an increase in relative consumption resulting in a strong positive correlation which is missing in the data (Backus and Smith 1993). In the literature, this is referred to as the Backus-Smith puzzle[1] or the consumption-real exchange rate anomaly (Chari, Kehoe and McGrattan 2002).

The latter might suggest that markets are incomplete and that world residents do not optimally share the risks of country-specific shocks (Kollman 1995). Nevertheless, market-incompleteness alone is not sufficient to break the tight link between consumption and real exchange rates (Chari, Kehoe and McGrattan 2002). This is largely because the optimal allocation under full international financial integration need not be very different from the allocation of an economy with a single, unconditional bond economy (Heathcote and Perri 2002) or even financial autarky (Cole and Obstfeld 1991), provided that shocks are not permanent (Baxter and Crucini 1995). Cole and Obstfeld (1991) call for an important role of the terms of trade in propagating the benefits of country-specific shocks via price changes, and suggest that the degree of substitutability of goods that are traded across countries can be important for the extent of risk-sharing that this mechanism can provide. Another possible explanation could be that cycles are driven by demand-type shocks, as in Stockman and Tesar (1995), since these disturbances can simultaneously increase both prices and quantities[2].

[1] For the remaining of the paper we abbreviate the latter to B-S.

[2] Corsetti et al (2006) and Enders and Müller (2009) show empirically that the US real exchange

We develop a two-country complete-market model with non-tradables that is able to reconcile these facts in a theoretical economy driven by sectoral productivity shocks, either expected or unexpected. The main contribution of our work is to propose an alternative explanation to the Backus-Smith puzzle based on news-shocks. News-shocks have the allure of changing agents' expectations about future income without changing current fundamentals. This very change in expectations generates strong wealth effects that act like a demand shock; driving up both prices and relative consumption and contributing to a low B-S correlation, significantly improving the model's fit to the data compared to the case of traditional, unexpected disturbances. Our result does not depend on market inefficiency or very low levels of trade elasticity (see Corsetti et al 2008). Instead it is the efficient allocation in an economy where the price of non-tradables plays an important role in real exchange rate movements, in accordance to the Harrod-Balassa-Samuelson (HBS) framework, and innovations to (sectoral) Total Factor Productivity (TFP) are known one period in advance. Nevertheless, any model driven by expected disturbances should also be consistent with an economic upturn following good news, and a recession following bad news. As is well known, it is surprisingly difficult for standard business cycle models to generate economic expansions following improved prospects about new technologies (Beaudry and Portier 2007, Jaimovich and Rebelo 2009). The novelty of our work is to lay down the theoretical underpinnings that allow the model to generate a worldwide economic boom conditional on anticipated innovations to productivity, while simultaneously generating empirically relevant movements in relative prices. Further, the model produces positive unconditional correlations of output, consumption, hours and investment across countries that are not far from their empirical counterparts.

The model possesses several distinctive features that contribute to our results. First, we assume preferences that exclude intertemporal substitution in labour effort, following Greenwood, Hercowitz and Huffman (1988, henceforth GHH). Eliminating the wealth effect in labour supply ensures a positive response of hours in both countries given expected shocks to tradables TFP. Most importantly though, GHH preferences introduce strong non-separabilities between consumption and leisure in the utility function, reducing the consumption-real exchange rate correlation. Second, we assume imperfect substitution of capital across sectors which triggers sizeable movements in the price of the non-tradable good, significantly reinforcing HBS effects.

rate and terms of trade fall following a permanent increase in manufacturing and aggregate TFP. Therefore, models that rely on productivity to drive business cycles (RBC paradigm) also need to be consistent with a low B-S correlation.

Indeed, in the economy where capital services are homogeneous the B-S correlation is positive and high, although it is dampened by wealth effects generated by news. Third, we allow for variable capacity utilisation which ensures an increase in the supply of labour and output in response to improved expectations about the future state of productivity, following the intuition in Jaimovich and Rebelo (2009). At the same time, variable capacity utilisaition amplifies the exogenous propagation mechanisms of the model (Jaimovich and Rebelo 2009, Burnside and Eichenbaum 1996, Baxter and Farr 2005), further intensifying the Balassa-Samuelson effect. In the context of our theoretical economy, variable capacity utilisation is an essential element to explain news-driven cycles and real exchange rate fluctuations.

Our paper is found in the intersection of the international business cycle literature and the news-shocks literature. Opazo (2006) and Nam and Wang (2010)[a] also investigate news-shocks as a potential source of the consumption-real exchange rate correlation in models where markets are incomplete. We show that a low B-S statistic can be the efficient allocation in an economy where expected improvements in productivity trigger an economic expansion. Benigno and Thoenissen (2008) construct a model where movements in non-tradables' prices are the main reason behind a negative B-S statistic in a world where a single bond is traded. Corsetti et al (2008) show that a standard incomplete-market model where the trade elasticity is low is consistent with a low degree of international risk sharing. Unlike Cole and Obstfeld (1991), their results suggest that movements in the terms of trade aggravate the risk-sharing problem, instead of mitigating it, in line with some empirical evidence (Corsetti et al 2006, Enders and Müller 2009). Raffo (2010) proposes a mechanism via investment-specific technology shocks to account for the consumption-real exchange rate anomaly, as this type of disturbances causes sizable shifts in domestic absorption and acts like a demand shock. As in our case, this mechanism can also work in complete-market environments but can be inconsistent with co-movements of investment across countries. Moreover, it has been shown to be less relevant once the exogenous process is estimated in the data (Mandelman et al 2011). Karabarbounis (2010) shows that accounting for a home-sector can potentially explain the observed limited degree of international risk sharing. Finally, the literature that tries to reconcile empirical business cycle facts with expected innovations to TFP has flourished since the early 2000s. Prominent examples include Beaudry and Portier (2004, 2006, 2007), Jaimovich and Rebelo (2008, 2009), Beaudry, Dupaigne and Portier (2011) and Schmitt-Grohé and Uribe (2012) . We add to this list an attempt to simultaneously account for movements in quantities *and* relative prices, in a frictionless open-economy model.

The following section outlines the model. Our main results are given in section three while section four scrutinises the mechanism that drives them, providing the model's underlying intuition. Section five reports some sensitivity analysis to selected parameter values and section six concludes.

2 The model

The model follows closely the workhorse international business cycle model of Backus, Kehoe and Kydland (1992, 1994) extended with a non-tradables sector. Additional features include GHH preferences, imperfect substitutability of capital services and variable capacity utilisation. There are two ex-ante symmetric countries, $i = 1, 2$. All exchanges take place in a common currency. Markets are perfect and complete. Time is discrete and infinite, $t = 0, 1, 2, ...$.

2.1 Production

There is full-specialisation in production of intermediate goods; country one produces intermediate good a and country two intermediate good b. Neither capital nor labour are mobile across countries but intermediate goods can be freely exchanged around the world. Output of intermediate goods is produced using a standard Cobb-Douglas production function:

$$\begin{aligned} Y_{at} &= Z_{1Tt}(S_{1Tt})^{\alpha_T}(N_{1Tt})^{1-\alpha_T} \\ Y_{bt} &= Z_{2Tt}(S_{2Tt})^{\alpha_T}(N_{2Tt})^{1-\alpha_T} \end{aligned} \tag{1}$$

where S_{ijt}, N_{ijt}, Z_{ijt} denote capital services (see below), labour and technology in country $i = 1, 2$.

Final-good producers are competitive. They purchase domestic and foreign intermediate goods at prices q_a^i and q_b^i, which are transformed into final goods via a constant-elasticity of substitution (CES) production function. Final goods are used locally for consumption (C_{iT}) and investment (Ii):

$$\begin{aligned} C_{1Tt} + I_{1t} &= \{\omega a_{1t}^{\frac{\theta-1}{\theta}} + (1-\omega) b_{1t}^{\frac{\theta-1}{\theta}}\}^{\frac{\theta}{\theta-1}} \\ C_{2Tt} + I_{2t} &= \{(1-\omega) a_{2t}^{\frac{\theta-1}{\theta}} + \omega b_{2t}^{\frac{\theta-1}{\theta}}\}^{\frac{\theta}{\theta-1}} \end{aligned} \tag{2}$$

We introduce home-bias in each country by allowing $\omega > 0.5$, and $\theta > 0$ is the elasticity of substitution between the two intermediate goods. For values of θ close to zero intermediate goods are complements, $\theta = 1$ corresponds to the Cobb-Douglas case and for $\theta \to \infty$ goods are perfect substitutes. The world's resource constraints for intermediate goods imply:

$$\begin{aligned} Y_{at} &= a_{1t} + a_{2t} \\ Y_{bt} &= b_{1t} + b_{2t} \end{aligned} \tag{3}$$

where a_{it} and b_{it} denote the use of good a and b in country i.

Moreover, each country produces a final non-tradable good using a Cobb-Douglas production function. We assume that these goods are used only for consumption, as in Corsetti et al (2008), Benigno and Thoenissen (2008) and Karabarbounis (2010).

$$\begin{aligned} C_{1Nt} &= Z_{1Nt}(S_{1Nt})^{\alpha_N}(N_{1Nt})^{1-\alpha_N} \\ C_{2Nt} &= Z_{2Nt}(S_{2Nt})^{\alpha_N}(N_{2Nt})^{1-\alpha_N} \end{aligned} \tag{4}$$

Following the literature, we maintain the assumption of homogeneous labour, and introduce sector-specific capital (Mendoza and Uribe 2000, Arellano et al 2009). In particular, we assume that the capital-services-transformation curve is a CES aggregator of sector specific-services:

$$\begin{aligned} u_{it}K_{it} &= g(S_T, S_N) = (S_{iTt}^{\frac{\varepsilon-1}{\varepsilon}} + S_{iNt}^{\frac{\varepsilon-1}{\varepsilon}})^{\frac{\varepsilon}{\varepsilon-1}} \\ N_{it} &= N_{iTt} + N_{iNt} \quad i = 1, 2 \end{aligned} \tag{5}$$

where u_{it} the rate of capacity utilisation and K_{it} is aggregate capital in country i. The parameter $\varepsilon > 1$ captures the elasticity of substitution of capital services across sectors. Perfect homogeneous capital services correspond to the case where $\varepsilon \to \infty$. The production possibility frontier is concave, owing to differences in factor intensities across the two sectors as well as to the curvature of aggregate services as given by $g(.)$. We view this function as a simple way of capturing imperfect substitutability of capital services across sectors, from the households' point of view. That is households, in lending their capital, have some preferences as to which sector their flows end to. For example during the internet bubble, households may have had some exogenous preference to invest in information technology. This would create a real friction in the financial markets with households requiring a different premium for lending capital to different sectors. As in Arellano et al (2009) and Mendoza and Uribe (2000), we remain agnostic about the exact functional form of the above in the real world, we rather see it as a simple way to add a real friction into the model. As we shall see, depending on the degree of substitutability, the price of non-tradables adjusts accordingly with important implications for the real exchange rate in the spirit of the Harrod-Balassa-Samuelson (HBS) framework. Finally, this approach has the practical appeal of being relatively simple, and we can easily check the implications of our model to different degrees of this elasticity, including homogeneous capital.

Aggregate consumption is a CES composite of tradable (C_{Ti}) and non-tradable goods (C_{Ni}):

$$C_{it} = \{\omega_T C_{iTt}^{\frac{\rho-1}{\rho}} + (1-\omega_T) C_{iNt}^{\frac{\rho-1}{\rho}}\}^{\frac{\rho}{\rho-1}} \quad i = 1,2 \tag{6}$$

where ω_T captures the preference for the tradable good and $\rho > 0$ is the elasticity of substitution between the two consumption goods.

2.2 Capital Accumulation

Capital stocks evolve according to:

$$K_{it+1} = (1-\delta(u_{it}))K_{it} + I_{it}\left(1 - S(\frac{I_{it}}{I_{it-1}})\right) \tag{7}$$

The depreciation rate is an increasing and convex function of capital utilisation such that $\delta'(u_{it}) > 0$, $\delta''(u_{it}) \geq 0$. Function S(.) represents investment adjustment costs, assumed to be zero at the steady-state, and is such that: $S(1) = 0$, $S'(1) = 0$ and $S''(1) > 0$. When we abstract from adjustment costs in the flow of investment we set $S(.) = 0$.

2.3 Households

Households are symmetric and their preferences are characterised by GHH-utility functions of the form:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_{it} - \psi N_{it}^{\nu})^{\gamma}}{\gamma} \quad \imath = 1,2 \tag{8}$$

where C_{it} and N_{it} are consumption and hours worked in country i. This type of preferences implies no wealth effects on labour supply.

2.4 Prices and equilibrium

As the production function in (2) is homogeneous of degree one, we have in equilibrium:

$$\begin{aligned} C_{1Tt} + I_{1t} &= q^1_{at} a_{1t} + q^1_{bt} b_{1t} \\ P_{2Tt}(C_{2Tt} + I_{2t}) &= q^2_{at} a_{2t} + q^2_{bt} b_{2t} \end{aligned} \tag{9}$$

where q^i_{at} and q^i_{bt} are the prices of the two intermediate goods in each country and P_{2Tt} is the price of the country-two good; all expressed in units of the country-one final tradable good (the numeraire). Obviously, with free movement of intermediate goods the law of one price holds: $q^1_{at} = q^2_{at} = q_{at}$ and $q^1_{bt} = q^2_{bt} = q_{bt}\ \forall\ t$. We thus define the terms of trade as the marginal rate of transformation between the two intermediate goods in country one evaluated at equilibrium quantities; which (in equilibrium) equals their relative price[3]:

$$p_t = \frac{q_{bt}}{q_{at}} = \frac{\frac{dY_{1Tt}}{db_{1t}}}{\frac{dY_{1Tt}}{da_{1t}}} = \Big(\frac{1-\omega}{\omega}\Big)\Big(a_{1t}/b_{1t}\Big)^{\frac{1}{\theta}} \tag{10}$$

Similarly, equilibrium in local markets requires that:

$$\begin{aligned} P_{1t}C_{1t} &= C_{1Tt} + P_{1Nt}C_{1Nt} \\ P_{2t}C_{2t} &= P_{2Tt}C_{2Tt} + P_{2Nt}C_{2Nt} \end{aligned} \tag{11}$$

where P_{it}, P_{iNt} are respectively the price of aggregate consumption and the price of non-tradables in country i. The price of the non-tradable good is defined as the marginal rate of transformation of the CES aggregator of final consumption (equation (6)):

$$\begin{aligned} P_{1Nt} &= \Big(\frac{1-\omega_T}{\omega_T}\Big)\Big(C_{1Tt}/C_{1Nt}\Big)^{\frac{1}{\rho}} \\ \frac{P_{2Nt}}{P_{2Tt}} &= \Big(\frac{1-\omega_T}{\omega_T}\Big)\Big(C_{2Tt}/C_{2Nt}\Big)^{\frac{1}{\rho}} \end{aligned} \tag{12}$$

The real exchange rate is defined as the relative price of aggregate consumption across countries:

$$Q_t = \frac{P_{2t}}{P_{1t}} \tag{13}$$

[3]Notice that this is not the standard definition of terms of trade, as it represents the relative price of imports (the foreign good) in terms of exports (the local good). However, this is consistent with the standard definition of the real exchange rate in macroeconomic models.

2.5 Shocks

Finally, we close the model by specifying the technology process which constitutes the exogenous variable in our system and the sole driving force of fluctuations:

$$\begin{pmatrix} Z_{1Tt} \\ Z_{2Tt} \\ Z_{1Nt} \\ Z_{2Nt} \end{pmatrix} = \begin{pmatrix} 0.82 & -0.06 & 0.10 & 0.24 \\ -0.06 & 0.82 & 0.24 & 0.10 \\ -0.02 & 0.02 & 0.96 & 0.01 \\ 0.02 & -0.02 & 0.01 & 0.96 \end{pmatrix} \begin{pmatrix} Z_{1Tt-1} \\ Z_{2Tt-1} \\ Z_{1Nt-1} \\ Z_{2Nt-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1Tt-q} \\ \varepsilon_{2Tt-q} \\ \varepsilon_{1Nt-q} \\ \varepsilon_{1Nt-q} \end{pmatrix}, \quad q \geq 0 \tag{14}$$

with the following variance-covariance matrix:

$$V = \begin{pmatrix} 0.047 & 0.022 & 0.009 & 0.004 \\ 0.022 & 0.047 & 0.004 & 0.009 \\ 0.009 & 0.004 & 0.009 & -0.001 \\ 0.004 & 0.009 & -0.001 & 0.009 \end{pmatrix} \times \frac{1}{100} \tag{15}$$

These parameter values are estimated by Corsetti et al (2008)[4]. Our exogenous process differs from those authors only for positive values of q. Shocks are pure surprises when $q = 0$, whereas assuming $q > 0$ allows the technology shock to be forecastable with certainty in advance (news-shock). Note that under this specification, shocks are either expected or not, irrespective of the country or sector of origin. It is worth emphasising that $q > 0$ does not change the exogenous sources of persistence and volatility of the system - compared to the original paper - since neither the matrix of autoregressive coefficients nor the volatility of the shocks have changed[5]. The mere change is in the timing of the shock. In other words, the two processes are observationally equivalent. That is, an econometrician trying to estimate equation (14) cannot know whether shocks are expected or unexpected. Therefore, we do not need to alter the coefficients of this system when changing the value of q.

2.6 Calibration, Steady-State and Solution Method

We calibrate all parameters of our model to annual data while following closely previous studies, especially Corsetti et al (2008) since we use the shock process estimated

[4]The authors estimate sectoral Solow residuals using annual data in manufacturing and services from the OECD STAN Database for the period 1970-2001. Country one is the US and country two is a "Rest of the World aggregate" comprised by EU-15, Canada and Japan.

[5]Any change would be endogenous, resulting from changes in the behaviour of rational agents in light of new information.

in their paper.

We choose a rate of time preferences β equal to 0.9615 that corresponds to an annual real interest rate of 4%. Following Jaimovich and Rebelo (2009), we set $\nu = 1.4$ corresponding to an elasticity of labour supply equal to 2.5, and ψ is adjusted so that at the steady-state agents spend 33% of their time on market activities. The elasticity of substitution of tradable intermediate goods seems to be one of the most controversial parameters in the open-economy literature. This is not only due to the uncertainty surrounding the empirical studies that attempt to estimate its value, but mostly for its important implications about the transmission mechanism of TFP shocks (see Cole and Obstfeld 1991, Corsetti et al 2008). According to Backus, Kehoe and Kydland (1994) the most reliable empirical studies estimate it between one and two, thus they calibrate it at 1.5, whereas Corsetti et al (2008) claim that the range of variation is wider, from 0.1 to 2 (see Hooper et al 2000). On the other hand, the trade industrialisation literature tends to assign higher values (see for example R. Jaef 2011). For our benchmark parametrisation we set trade elasticity to two, which is a bit higher compared to BKK but well within the range of estimates mentioned above. This value is also used by Benigno and Thoenissen (2008) and Karabarbounis (2010) estimates it to 1.907. As part of our sensitivity analysis we test the performance of our model to different values.

We assume that the two final goods are complements in consumption ($\rho = 0.74 < 1$). This value is estimated by Mendoza (1991) and used by Corsetti et al (2008). Stockman and Tesar (1995) set this parameter lower to 0.44 but their sample includes developing countries as well. The degree of home-bias is calibrated assuming an import share equal to 5% while the bias toward the tradable consumption good is set assuming that its share in aggregate consumption is 47%, following closely Corsetti et al (2008). As for the production function, we assume that the labour share is 61% in tradables production and 56% in non-tradables production[6]. We assume a level of investment adjustment costs equal to 0.039. This value is lower than in other studies where it is often chosen to match the relative variance of investment. In our model, investment is not too volatile so we set κ to the minimum value consistent with expectations-driven cycles following a news-shock to the tradables sector in country one under the benchmark parametrisation (see more below). We choose to focus on the tradables sector since it is the main driver of aggregate fluctuations.

We now move on to the choice of the elasticity of substitution of capital services,

[6]Corsetti et al (2008), whose exogenous process we adopt, estimate Solow residuals under these assumptions.

Table 1: Parametrisation

Preferences		
$\beta = 0.9615$	Discount factor	Annual interest rate of 4%
$\frac{1}{\nu-1}$	Elasticity of labour supply at 2.5	Jaimovich and Rebelo (2009)
$\gamma = -1$	Risk Aversion equal to two	Backus, Kehoe and Kydland (1994)
ψ	Steady-state labour supply: 33%	Corsetti et al (2008)
Elasticity of substitution		
$\theta = 2$	Home and foreign intermediate good	Benigno and Thoenissen (2008)
$\rho = 0.74$	Tradable and Non-tradable good	Mendoza (1991)
$\varepsilon = 2$	Capital Services	Estimated
Bias		
$\omega = 0.772$	Home bias	Import share: 5%
$\omega_T = 0.436$	Bias in tradables consumption	Consumption share of tradables: 47%
Technology		
$\alpha_T = 0.39$	Capital share in tradables production	Corsetti et al (2008)
$\alpha_N = 0.44$	Capital share in non-tradables production	Corsetti et al (2008)
$\delta = 0.10$	Annual depreciation rate	
Investment		
$\kappa = 0.039$	Level of adjustment costs	Positive responses to expected shock
Utilisation		
$\frac{\delta''(\bar{u})}{\delta'(\bar{u})}\bar{u} = 0.15$	Elasticity of marginal depreciation	Jaimovich and Rebelo (2009)

for which to our knowledge there are no empirical estimates[7]. Given the uncertainty and lack of empirical evidence surrounding the value of this parameter, we estimate it as to minimise the distance between theoretical and empirical correlations of the real exchange rate with respect to relative output, terms of trade, and the net exports to GDP ratio[8]. Strong HBS effects are likely to drive the first two moments in opposite directions, so including them in the estimation ensures a fair balance between the two. The last moment helps to resemble the co-movements in relative prices and international trade flows as in the data. Note that in models where the real exchange rate is driven primarily by movements in the price of non-tradables, a low B-S correlation is usually obtained at the cost of a low correlation between the real exchange rate and the terms of trade (Corsetti et al 2011, Benigno and Thoenissen 2008); thereby it is important to include the latter statistic in our minimization problem to discipline our results. For this reason, we perform the exercise also using only the last two moments, i.e. the correlation of the real exchange rate with the terms of trade and with the ratio of net exports over GDP. As mentioned, investment adjustment costs are necessary in our model to ensure positive response of hours, investment and output following an announced increase in tradables TFP. We would like to choose the lowest value consistent with the latter. Therefore, we proceed our exercise as follows: first, we run our method of moments estimation for ε in economies driven by unexpected shocks to TFP, using a relatively high value of the investment adjustment cost parameter (0.048). Such a value ensures that the model produces expectations-driven booms, once shocks are allowed to be anticipated, for any degree of capital substitutability. This exercise gives an optimum value of ε equal to 1.944 if we take into account all the three moments and 2.007 if we include only the last two; therefore we round-up this estimate to 2. At this value, the calibrated choice for the investment-adjustment cost parameter is 0.039. Note that the minimum distance estimator of ε when $\kappa = 0.039$ is still very close to two, validating our choice[9].

[7]Mendoza and Uribe (2000) calibrate it to -0.11 for Mexican data because this value ensures that the response of the non-tradables' price to a "devaluation-risk shock" matches the empirical one estimated in a Vector Autoregression (VAR). Arellano et al (2009) use this value for Ivory Coast, simply following these authors. However, simply adopting this value would not be appropriate since we focus on developed economies.

[8]Specifically, we estimate the sum of quadratic deviations of model-estimated (asymptotic) moments vis - à - vis the data. We select the value of ε that minimises the quadratic loss function. Moments are equally weighted, which ensures that the general method of moments estimator is unbiased and consistent. Our experiments concern economies driven by surprise shocks.

[9]In particular, it is 2.086 if we take two moments into account and 2.025 for three moments. Figure 13 in the Appendix plots these loss functions. They are both well defined and a global minimum is attained.

Finally, we discuss issues concerning capacity utilisation. The depreciation function is assumed to be quadratic of the form:

$$\delta(u_t) = \delta_0 + \delta_1(u_{it} - \overline{u}_i) + \frac{\delta_2}{2}(u_{it} - \overline{u}_i)^2 \tag{16}$$

Setting $\delta_0 = 0.1$ we ensure that the depreciation rate is 10% per annum at the steady-state. Moreover, we assume a constant steady-state utilisation rate (equal to unity) and we calibrate the elasticity of marginal depreciation to $\frac{\delta''(\overline{u})}{\delta'(\overline{u})}\overline{u} = \frac{\delta_2}{\delta_1}\overline{u} = 0.15$, following Jaimovich and Rebelo (2009). As these authors explain, a low elasticity of $\delta'(u)$ implies that utilisation is more responsive to shocks, resulting in a powerful amplification mechanism.

Given the parameters, we solve the problem of the social planner who weights both countries equally. We log-linearise the model around the symmetric, non-stochastic steady-state and we solve it using standard numerical methods.

3 Results

3.1 Unconditional Correlations

In this section we describe our benchmark results, which are presented in Table 2. Both empirical and model-generated data are HP-filtered with a smoothing parameter equal to 100. Theoretical moments are asymptotic.

First, we note that in this benchmark parametrization, the model is able to generate positive correlations of economic aggregates across countries for any type of shock. For shocks that are pure surprises we match very well the empirical correlation of consumption and hours across countries, whereas the investments correlation is a bit higher than in the data. Results are not altered significantly in news-driven economies. However, the model produces a higher correlation in consumption than output when we observe the contrary in the data.

The most novel result of the paper is that the consumption-real exchange rate correlation is negative. Most importantly, it is only slightly negative (−0.054) in a world where shocks are unexpected, but improves significantly to −0.224 in news-driven cycles. Wealth effects generated by news are so strong that the B-S correlation drops by almost 20 percentage points; well into the negative region. Abstracting from a slightly lower correlation between the real exchange rate and the terms of trade, this significant improvement comes at no cost, especially in terms of international co-movements. At the same time a worldwide economic expansion pursues good news

Table 2: Baseline Model

	Data	Unexpected Shocks	News Shocks
St. Deviation relative to GDP			
Consumption	0.94	0.602	0.572
Investment	4.33	1.993	2.072
Hours	1.19	0.663	0.658
Real Exchange Rate	3.90	0.085	0.131
Terms of Trade	1.68	0.241	0.218
Relative Price of NT	0.86	0.239	0.303
Correlation between real GDP and			
Real Net Exports	-0.48	-0.443	-0.467
International co-movements			
Outputs	0.68	0.452	0.432
Consumptions	0.60	0.588	0.546
Hours	0.54	0.511	0.498
Investments	0.25	0.353	0.362
Correlation between RER and			
Rel. Consumption	-0.42[1]	**-0.054**	**-0.224**
Rel. Output	-0.19	-0.118	-0.315
Terms of Trade	0.52	0.013	-0.052
Real NX over GDP	0.60	0.293	0.541

[1]Median of bilateral US dollar real exchange rates across 16 industrialised countries (source: Corsetti et al 2008). The data column was adapted from Corsetti et al (2008). Both empirical and model-generated data are HP-filtered with a smoothing parameter equal to 100. Theoretical moments are asymptotic.

about the future state of productivity (see below).

The model also generates a negative correlation between the real exchange rate and relative output and a positive correlation with real net exports; the latter improving remarkably in news-driven economies. Other successful features include countercyclical net exports and strong pro-cyclical movements in employment, investment and consumption within countries (not shown). On the other hand, the model generates too little volatility, especially for relative prices - a common problem of open-economy models (BKK, Heathcote and Perri 2002). Nevertheless, the real exchange rate is almost twice as volatile in the news-driven economy. Finally, the correlation between the terms of trade and the real exchange rate is around zero in both cases but positive in the data, for reasons we discuss below.

3.2 International Co-movements

The main insight of our model is that news-driven international cycles as discussed in Beaudry, Dupaigne and Portier (2011) and Jaimovich and Rebelo (2009) can also be consistent with a negative correlation between the real exchange rate and relative consumption.

Consider an anticipated shock to the tradables TFP in country one. Impulse responses are given in figure 1. Investment adjustment costs provide an incentive

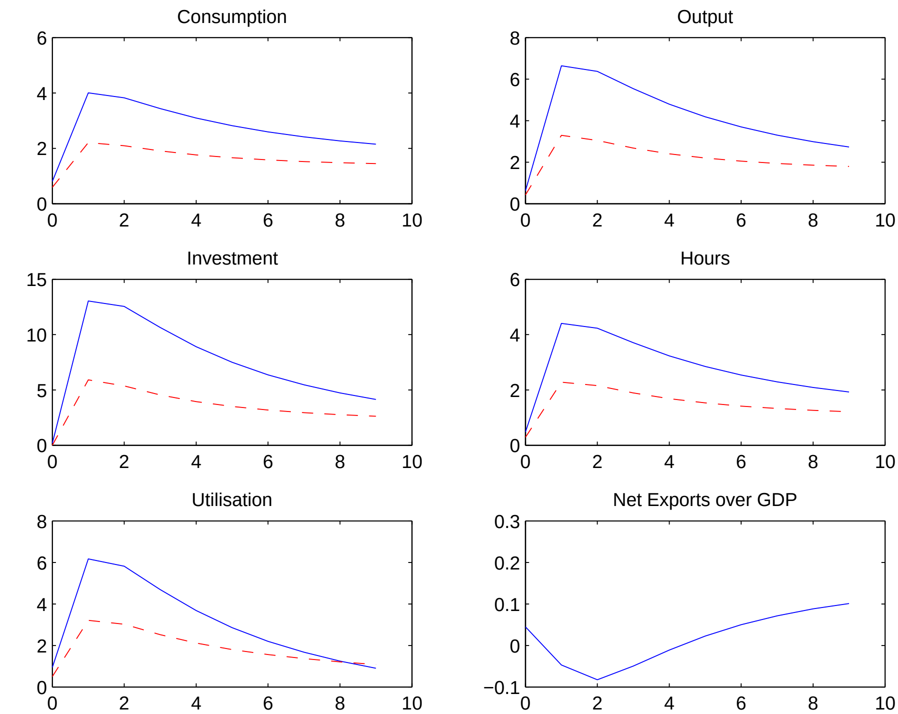

Figure 1: World expansion generated by an expected shock to the tradables sector TFP of country one. Solid lines: country one. Dashed lines: country two. Percentage deviations from steady-state, except for net exports.

for investment smoothing so that the response is positive on impact. An increase in investment today lowers the value of installed capital since adjustment costs mean that higher investment today lowers the cost of augmenting the capital stock in the future. As capital is less valuable, it becomes efficient to increase its rate of utilisation. The latter increases the marginal productivity of labour hence, given zero wealth effects on labour supply, workers postpone leisure raising hours and output. In the foreign country agents also anticipate a future increase in their income, coming from positive cross-country productivity spillovers, since we assume that news is a common, public announcement. Therefore, the response is similar to that of country one but weaker.

Jaimovich and Rebelo (2009) show that preferences with low wealth effects on labour supply, investment adjustment costs and variable capacity utilisation are consistent with a pro-cyclical response to news about a permanent change in TFP, in a single-sector, closed-economy model[10]. A major contribution of our work is to extend their analysis to a two-country world consistent with news-driven economic expansions both within and across countries. These elements serve as a powerful

[10]In an earlier part of their work (Jaimovich and Rebelo 2008) they derive similar results in the context of a small open-economy model.

source of international business cycle synchronization under expected shocks to the (tradables) TFP. On the other hand, Beaudry and Portier (2007) show that cost-complementarities can also deliver within country co-movements in a multi-sector economy for as long as the elasticity of labour supply is not too low. Beaudry, Dupaigne and Portier (2011) develop a multi-sector model of national and international business cycles with complementarities between capital and labour in the production of the consumption good, as well as sector-specific factors of production. We show that complementarities are not necessary once we allow for the elements of our model.

To sum up, we have shown that our model is able to replicate two of the most well-known empirical facts of international macroeconomics; yet amongst the most troublesome to replicate in theoretical models: positive international co-movements of economic aggregates (both unconditionally and conditional to a news-shock) and a negative correlation between relative consumption and the real exchange rate. In what follows, we analyse the mechanisms that drive our results - especially with respect the B-S correlation. We check the Balassa-Samuelson effect, a model with both expected and unexpected innovations, substitutability of capital services and capacity utilisation. In doing so, we contrast the implications of our model to other parts of the literature. In the last section, we check our model's sensitivity to chosen parameter values.

4 Inspecting the mechanism

4.1 The Balassa - Samuelson effect

There is no consensus on the impact of sectoral productivity differentials and the relative price of non-tradables on real exchange rate movements. Kakkar (2003), Bergstrand (1991), De Gregorio and Wolf (2004) and Corsetti et al (2006) document empirical evidence in favour of Balassa-Samuelson effects, whereas Betts and Kehoe (2006) document an important role for the relative price of non-tradables to the US-Canada and US-Mexico real rate (see also Mendoza and Uribe 2000). On the other hand, Engel (1999), Engel and Rogers (1996) and Chari, Kehoe and McGrattan (2002) find that most of the real exchange rate variability is due to tradables and deviations from the law of one price.

Consider a temporary, but persistent, TFP shock to the home tradable-good sector alone[11]. Efficiency requires that the price of the home-intermediate good falls and the terms of trade depreciate. At the same time, sectoral marginal productivity increases and drives up real wages, which are equalized across sectors by the assumption of labour mobility. Consequently, higher wages in the non-tradable sector at almost constant productivity levels[12] imply an unavoidable increase in the price of the non-tradable good; this is exactly the Balassa-Samuelson effect. The response of the real exchange rate will depend on the relative strength of the two effects: the terms of trade effect that pushes towards a depreciation and the Balassa-Samuelson effect that pushes towards an appreciation. Under our parametrization, the first effect wins and the real exchange rate depreciates on impact (see Figure 2). However, the real exchange rate moves on a downward path for one period (appreciation) and then depreciates for several years before returning to its initial level. On the other hand, the path of relative consumption is very different. On impact, home-bias drives home-consumption higher and thereafter consumption-smoothing prevails to ensure a smooth, downward path. Consequently, the correlation between the two variables is low.

The dynamics are a bit different when TFP improvements are perfectly anticipated one period in advance, where wealth effects contribute to an even lower correlation between the real exchange rate and relative consumption, bringing it well below zero. Impulse Response Functions (IRFs) of prices are given in figure 3. Where faced with unexpected technology improvements the terms of trade depreciate to reflect the scarcity of the foreign good; they depreciate in response to positive news about the future to reflect the fall in the *relative demand* of the home good. Nevertheless, the depreciation is considerably smaller than for unexpected shocks[13]. The relative price of the home non-tradable good also falls, implying an overall depreciation of the real exchange rate. The intuition is that following the announcement, the home-country enjoys a higher wealth effect; a demand-side effect that pushes towards an appreciation. For the same reason, though, utilisation increases more in the home-country, increasing relative supply and creating forces towards a depreciation. Given the model's features and the specified parametrization, the latter effect dominates and the real exchange rate depreciates on impact[14]. Thereafter, the real exchange rate

[11] We choose to analyse responses to shocks in the tradables sector TFP as these are the main drivers of cycles. Responses to shocks to the non-tradables sector productivity are provided in the appendix (figures 11 and 12).

[12] Productivity in the non-tradables sector increases a bit due to positive sectoral spillovers.

[13] Our previous work shows that even in the frictionless, one-sector, two-country BKK model the positive impact response of the terms of trade falls monotonically with news (Lambrias 2012).

[14] Differently, the social planner chooses an equilibrium with lower prices but higher output for

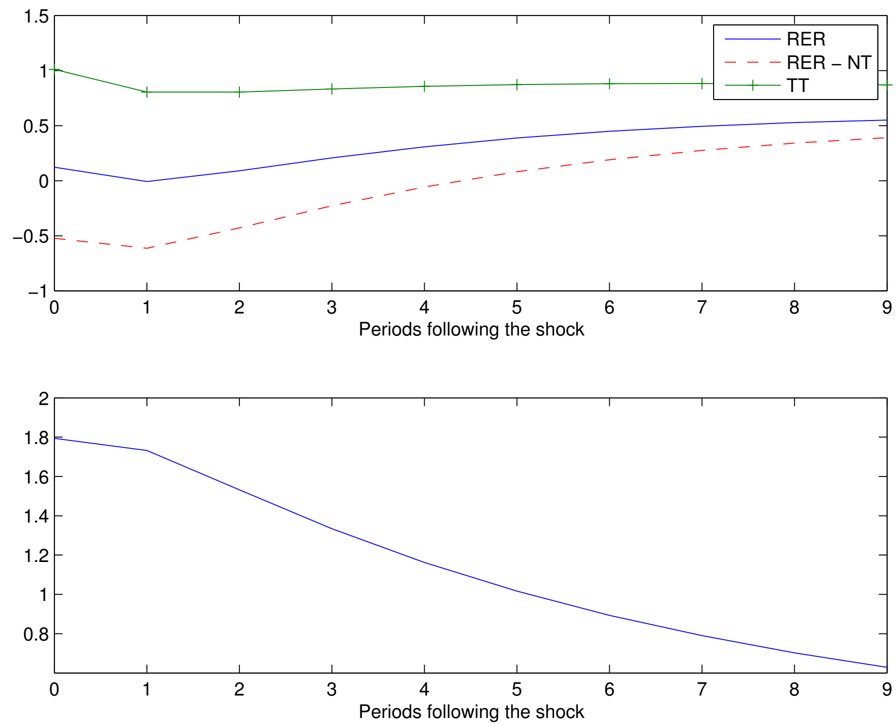

Figure 2: The response of relative prices (upper panel), i.e. the real exchange rate (RER), the terms of trade (TT) and the relative price of non-tradables (RER-NT), and relative consumption (lower panel) to one standard deviation unexpected shock to the tradable-goods sector. Percentage deviations from the steady state.

follows a downward path for one period when relative consumption increases. This discrepancy in the response of the two variables during the interim-period (between the announcement and the TFP change) drives their correlation down. Abstracting from the impact response, the two variables move in opposite direction for two periods instead of one as was the case for surprise shocks. Had the news arrived two periods in advance, they would be moving so for three periods and so on; which explains why the B-S statistic falls monotonically with the length of the interim period[15].

Our work suggests an alternative explanation to the consumption-real exchange rate anomaly, revolving around news-shocks. Strong wealth effects brought about by the arrival of good news about future TFP contribute to a significantly lower B-S correlation. In our paper, these effects do not rely on a low degree of substitutability between the home and the foreign good or on incomplete markets in order to arise. Instead, a negative B-S correlation is the efficient allocation in an economy where wealth effects on labour supply are very low, HBS effects are relatively strong, the elasticity of substitution of tradables is within the range of empirical estimates and shocks are anticipated one period in advance. A simultaneous rise in the price of the home-good and relative consumption can also emerge from taste shocks, as in Stockman and Tesar (1995), but these shocks are hard to measure in the data (Mandelman et al 2011). Since wealth effects come about from the exogenous process of our model, and since news-shocks do not increase current efficiency, they are similar to taste shocks. However, TFP disturbances can be more accurately estimated in the data, while our exogenous process is consistent with empirical evidence that TFP innovations are to a large extent anticipated and can have important implications for our understanding of cyclical fluctuations (Beaudry and Portier 2006).

The model follows the intuition in Corsetti, Dedola and Viani (2011): in a complete-market world, perfect risk sharing implies that the terms of trade depreciate following a TFP shock to ensure a positive international transmission of productivity shocks. Thus, the correlation between the real exchange rate and relative consumption can be low or negative only via strong Balassa-Samuelson effects, as in our case. Nonetheless, this comes at an unavoidable cost: a low and sometimes negative correlation between the real exchange rate and the terms of trade. Note that this is not ultimately connected to efficiency. Benigno and Thoenissen (2008) develop a model with incomplete markets where the B-S result is achieved via Balassa-Samuelson ef-

the country that receives the good news and higher prices and lower output for the other. This is the optimal way to share the wealth effect generated.

[15] We analyse the performance of our model to lengthier interim periods later.

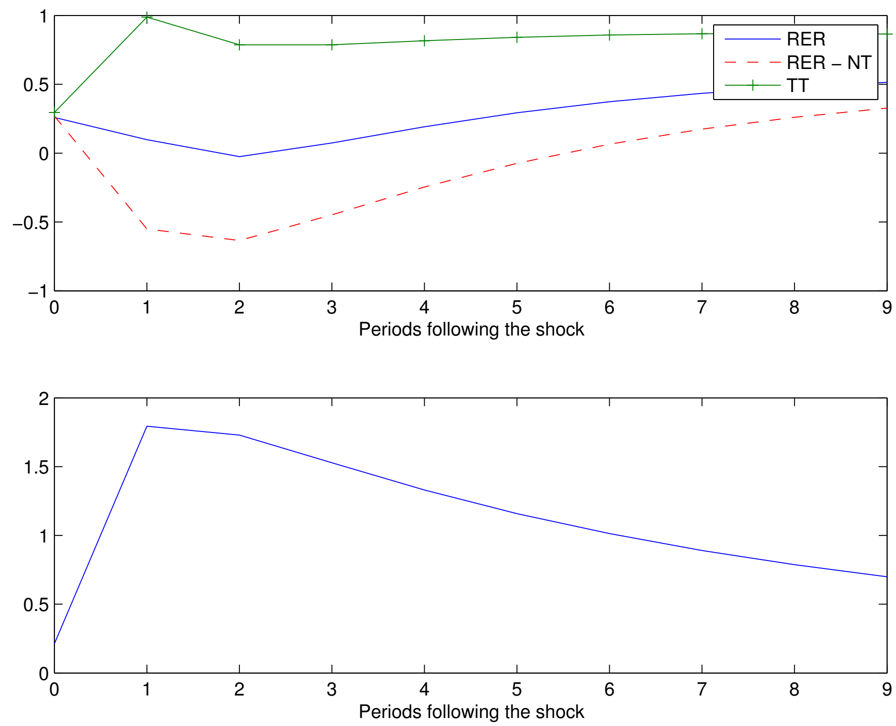

Figure 3: The response of relative prices (upper panel), i.e. the real exchange rate (RER), the terms of trade (TT) and the relative price of non-tradables (RER-NT), and relative consumption (lower panel) to one standard deviation expected shock to the tradable-goods sector. Percentage deviations from the steady state.

fects but the correlation between the real exchange rate and the terms of trade is still negative. At the same time, Cole and Obstfeld (1991) and Heathcote and Perri (2002) show that the terms of trade depreciate even in conditions of financial autarky in order to account for the missing financial markets. Corsetti et al (2008) propose an alternative mechanism in incomplete markets: TFP improvements endogenously generate wealth effects that are so strong that result in a marked rise in demand and drive up all prices. No matter how intuitive this argument is, it requires a much lower value of trade elasticity relative to those used in the literature (between 1-2); a point made also by Karabarbounis (2010). Corsetti, Dedola and Vianni (2011) document empirically that this channel is important to explain the low degree of international risk sharing. Enders and Müller (2009) support this view by showing that the international transmission mechanism of permanent TFP shocks is consistent with a model where the elasticity of substitution is low and international markets are incomplete.

Alternatively, Karabarbounis (2010) shows that a model that accounts for a home-sector is consistent with a low degree of international risk-sharing. The intersection of our work with Karabarbounis lies in the choice of the utility function. As Benhabib et al (1991) have shown, GHH-preferences are consistent with standard preferences in a model with a home-sector where both market and non-market consumption are perfect substitutes; as are market and non-market work. Similarly, strong non-separability of consumption and leisure ensures a lower B-S correlation consistent with an increase in labour supply to an expected TFP shock (Jaimovich and Rebelo 2009).

Raffo (2010) proposes an alternative story to explain the consumption-real exchange rate anomaly, hinging on investment-specific technology (IST) shocks (see also Rabanal et al 2008). As he explains, such shocks cause big shifts in domestic absorption, such that aggregate demand exceeds supply and the terms of trade have to appreciate to clear the market. How appealing this mechanism can be, it implies a low, if not negative, correlation of investment across countries. The non-tradables sector in our model and the strength of the Balassa-Samuelson effect decrease the importance of this mechanism and can provide a low B-S correlation without huge differences in relative investment[16]. Raffo's work has also been criticised by Mandelman et al (2011) who show that once IST shocks are estimated in the data, his model's quantitative implications can be significantly altered. In our model we fit exogenous sectoral-TFP shocks as estimated in the data. Moreover, even-though

[16]Note that investment-specific shocks and news-shocks to TFP share a common feature: they do not affect current aggregate efficiency, resembling taste-shocks. Yet, our model is successful in generating a negative B-S correlation and a positive cross-country investment correlation.

investment-specific shocks can produce more volatile relative prices, our news-driven economy implies an increase in the real exchange volatility by a factor of 1.5.

Finally, our work adds to the vastly growing literature of expected innovations. Beaudry and Portier (2004, 2007) and Jaimovich and Rebelo (2009) develop models that are consistent with within-country news-driven cycles, whereas Beaudry, Dupaigne and Portier (2011) extend the latter to international co-movements. We show that wealth effects generated by news can also help us better understand movements in relative prices. To our knowledge, Opazo (2006) was the first to consider news-shocks as a possible explanation of the B-S puzzle via demand-side effects, but in his model investment and employment in both countries *fall* in response to news and the unconditional correlation of investment across countries is negative[17]. Moreover, the theoretical B-S correlation is low but not negative. Our model improves on Opazo's work by generating world expansions following improved technological prospects, a relatively strong B-S statistic and positive unconditional correlations. In a similar spirit, Nam and Wang (2010)[a] observe that the US terms of trade and real exchange rate appreciate when US labour productivity is high[18]. They show that this behavior can be replicated in an incomplete markets model with monopolistic competition, sticky prices and producer currency pricing driven by expected shocks to permanent productivity. Our analysis complements theirs since we show that a negative B-S correlation need not be necessarily connected to lack of risk sharing, imperfect competition, money or other frictions in news-driven environments.

4.2 Expected and Unexpected Innovations

A fair criticism to our benchmark model is that shocks are either perfectly anticipated or pure surprises, but we do not allow for an intermediate case. In this section we analyse the performance of the model that allows for both unexpected and expected innovations together. In doing so, the exogenous process is now given by the following system:

[17]Note also that Opazo (2006), assumes news to be an imperfect public signal.

[18]Enders and Müller (2009) show that technology shocks as identified in a SVAR with long-run restrictions appreciate the US terms of trade. Corsetti et al (2006) obtain a similar response to permanent TFP shocks in manufacturing, their proxy for the tradables sector. Alquist and Chinn (2002) show that a one percentage point increase in the US - Euro Area productivity differential can imply up to a five percent appreciation in the dollar-euro real exchange rate, we get similar results using SVAR and cointegration methods to identify permanent world technology shocks (Lambrias 2011). Interestingly, Nam and Wang (2010)[b] show that news-shocks to technology are associated with a US terms of trade appreciation whereas unexpected disturbances are associated with a depreciation.

$$
\begin{aligned}
\mathbf{Z_t} &= \mathbf{A}\mathbf{Z}'_{\mathbf{t-1}} + \mathbf{w_t} \\
\mathbf{w_t} &= \epsilon_{\mathbf{t}} + \mathbf{u_{t-1}}, \;\; \epsilon_t \perp u_s \forall s, t
\end{aligned}
\tag{17}
$$

As above, $\mathbf{Z_t} = (Z_{1Tt}\, Z_{2Tt}\, Z_{1Nt}\, Z_{2Nt})'$ and matrix A is the persistence matrix in equation (14). Under this specification, the innovation is split in two components, the unexpected one $\epsilon_{\mathbf{t}} = (\epsilon_{1Tt}\, \epsilon_{2Tt}\, \epsilon_{1Nt}\, \epsilon_{2Nt})'$, and one that is perfectly anticipated one period in advance, $\mathbf{u_t} = (u_{1Tt}\, u_{2Tt}\, u_{1Nt}\, u_{2Nt})'$. Since the two components are orthogonal to each other, the overall variance of the innovation $\mathbf{w_t}$ is equal to the sum of the variance of the two elements. This allows us to check how the predictions of the model change as we allocate the "overall" variance of the shock $\mathbf{w_t}$ to its respective components. Thus, we set the variance of $\mathbf{w_t}$ equal to the one estimated in Corsetti et al (2008) and we vary the proportion of it that is allocated to the expected part, at increments of 5%[19]. We keep the value of the elasticity of substitution of capital services equal to two as it was estimated under the case of purely unexpected innovations above, and each time we check for the lowest value of the investment adjustment cost parameter at which an economic expansion follows an increase in u_{1Tt}. As it turns out, even when we allocate only 5% of the overall variability to the expected component, we still need $\kappa = 0.039$; as in the benchmark case. That means that the minimum value of κ that is consistent with Pigou cycles is the same no matter the relative importance of expected sectoral innovations in TFP. We therefore keep both the value of the elasticity of substitution in capital services and the level of investment adjustment costs fixed as in the benchmark case; $\varepsilon = 2$ and $\kappa = 0.039$ respectively.

The correlation between the real exchange rate and its relative price drops monotonically as we increase the proportion of the variability allocated to the news-shock (Figure 4). Thus, not only the economy with purely anticipated TFP shocks significantly improves the B-S correlation without jeopardizing the rest of the model's features; even in cases where we allow for both a surprise and an expected innovation, the more important the latter is in driving cyclical movements, the lower the B-S statistic. In order to evaluate different models depending on the importance of expected innovations, we create a loss function. This is defined as the sum of the quadratic deviations of model-generated data with their empirical counterparts. As we did in estimating ε, we exclude from the estimation of the loss function the cor-

[19]The proportion of variance across sectors is also maintained constant. Further, we allocate the same proportion of the overall co-variance to each component as we do with the variance.

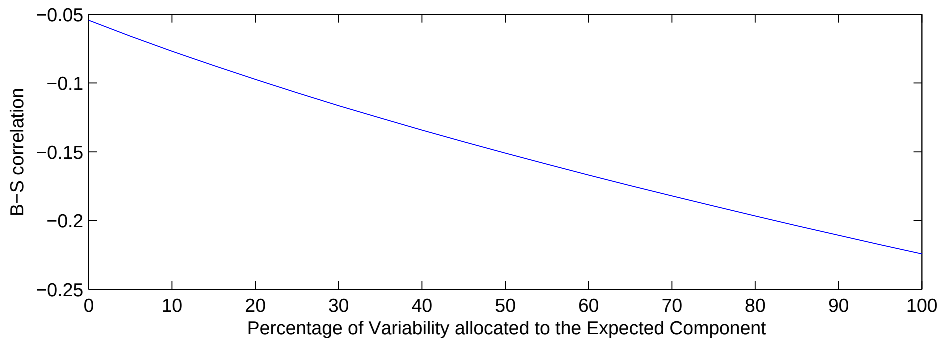

Figure 4: The Backus-Smith correlation as a function of the percentage of the overall variance allocated to the expected component.

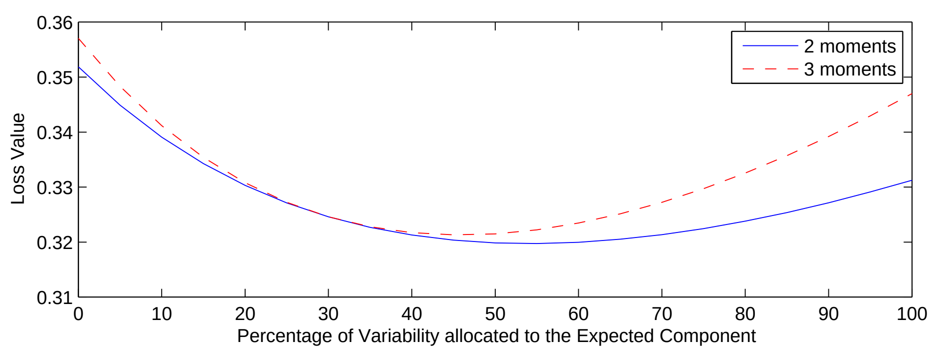

Figure 5: The value of the Loss Function as we vary the proportion of the overall variance attributed to the expected innovation. The Loss Function refers to the quadratic deviation of model-generated data and their empirical counterparts. These moments are the correlation between the real exchange rate and relative output, terms of trade and net exports over GDP (3 moments) and the correlation between the real exchange rate and the terms of trade and net exports over GDP (2 moments).

Table 3: Unexpected and Expected Innovations

	Data	News account for 50% of the overall variance
St. Deviation relative to GDP		
Consumption	0.94	0.587
Investment	4.33	2.032
Hours	1.19	0.661
Real Exchange Rate	3.90	0.110
Terms of Trade	1.68	0.230
Relative Price of NT	0.86	0.272
Correlation between real GDP and		
Real Net Exports	-0.48	-0.454
International co-movements		
Outputs	0.68	0.442
Consumptions	0.60	0.569
Hours	0.54	0.505
Investments	0.25	0.358
Correlation between RER and		
Rel. Consumption	-0.42[1]	**-0.151**
Rel. Output	-0.19	-0.231
Terms of Trade	0.52	-0.023
Real NX over GDP	0.60	0.443

[1]Median of bilateral US dollar real exchange rates across 16 industrialised countries (source: Corsetti et al 2008). The data column was adapted from Corsetti et al (2008). Both empirical and model-generated data are HP-filtered with a smoothing parameter equal to 100. Theoretical moments are asymptotic.

relation between the real exchange rate and relative consumption; and instead we focus on the correlation of the real exchange rate with respect to relative output, terms of trade and the net exports over GDP ratio (equally weighted). When taking into account all those moments, the loss function is minimised when 45% of the overall variability of the exogenous process is allocated to the news-shock (see figure 5, dashed-line), and at 55% when taking into account only the last two; i.e. the correlation between the real exchange rate and the terms of trade and real exchange rate and net exports (see figure 5, solid line). Thus, according to our metric, the best model is one where approximately half of the overall variance of innovations is allocated to sectoral TFP shocks that are perfectly anticipated one period in advance. The results for that case are provided in Table 3. The B-S correlation stands at -0.151, higher than in the benchmark model but still well into the negative territory. At the same time, and as in the benchmark case, positive unconditional correlations of economic aggregates across countries prevail and a worldwide economic expansion follows a positive expected innovation to the tradables TFP.

4.3 Imperfect Substitutability of Capital Services

The simple Balassa-Samuelson model has difficulty replicating observed movements in relative prices. Factor homogeneity has strong implications about the behaviour of the

Table 4: Homogeneous Capital Model

	Data	Unexpected Shocks	News Shocks
St. Deviation relative to GDP			
Consumption	0.94	0.638	0.609
Investment	4.33	1.902	1.977
Hours	1.19	0.683	0.680
Real Exchange Rate	3.90	0.129	0.147
Terms of Trade	1.68	0.240	0.216
Relative Price of NT	0.86	0.184	0.235
Correlation between real GDP and			
Real Net Exports	-0.48	-0.427	-0.455
International co-movements			
Outputs	0.68	0.461	0.438
Consumptions	0.60	0.580	0.539
Hours	0.54	0.510	0.496
Investments	0.25	0.365	0.368
Correlation between RER and			
Rel. Consumption	-0.42[1]	**0.770**	**0.513**
Rel. Output	-0.19	0.728	0.430
Terms of Trade	0.52	0.659	0.531
Real NX over GDP	0.60	0.516	-0.128

[1]Median of bilateral US dollar real exchange rates across 16 industrialised countries (source: Corsetti et al 2008). The data column was adapted from Corsetti et al (2008). Both empirical and model-generated data are HP-filtered with a smoothing parameter equal to 100. Theoretical moments are asymptotic.

relative price of non-tradables and consequently the real exchange rate in models like ours where the law of one price for tradables always holds. If factors are homogeneous, movements in the price of non-tradables depend on relative factor shares across sectors $(\alpha_T - \alpha_N)$ and changes to sectoral capital-labour ratios. Empirically, however, there seems to be little evidence on the massive sectoral shifts in capital-labour ratios required to produce large movements in the price of non-tradable goods (Mendoza and Uribe 2000). Thereby, allowing capital to be sector-specific can be potentially promising as the prices would react to reflect the degree of substitutability. This section analyses quantitatively this channel.

The consumption-real exchange rate anomaly arises in a world where capital services are perfectly substitutable (function $g(.)$ is linear). Statistics for this economy are given Table 4 and the mechanism is presented graphically in figure 6[20]. The tradables-sector is the most important one because of higher variability of TFP shocks and because investment is limited to this sector. Imperfect capital substitutability creates a bias towards tradables, as it can be seen by the relative response of capital services across sectors $S_{T1t} - S_{N1t}$ in the different economies (figure 6, lower panel). The difference in the capital allocated across sectors is much higher in the benchmark economy compared to the perfect-substitutability case. Similarly, the lower the sub-

[20]For what follows, the analysis is within country one.

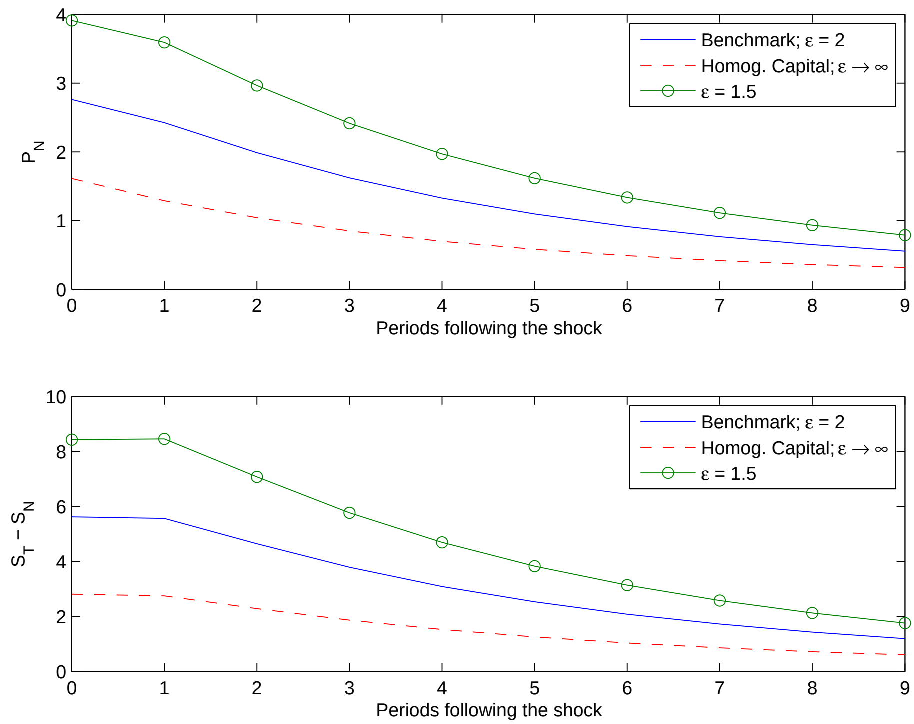

Figure 6: Response of the price of non-tradables (P_N, upper panel), and the capital services differential across sectors ($S_T - S_N$, lower panel) to an unexpected shock to tradables TFP, for different values of ε. Percentage deviations from steady-state.

stitutability of capital the higher this difference, as can be seen in the response of $S_T - S_N$ for $\varepsilon = 1.5$ and the associated response of P_N. More intense use of capital in the tradables sector boosts the marginal product of labour and consequently the wage; exactly in line with the Balassa-Samuelson doctrine but only stronger. To demonstrate this argument in the context of our model, using the first order conditions of capital and labour across sectors, and doing some algebra gives:

$$\tilde{P}_N = \underbrace{\frac{\alpha_T}{\alpha_N}\frac{Z_T}{Z_N}\left(\frac{S_T}{N_T}\right)^{\alpha_T-1}\left(\frac{S_N}{N_N}\right)^{-\alpha_N-1}}_{HBS\,effect}\underbrace{\left(\frac{S_T}{S_N}\right)^{1/\varepsilon}}_{Effect\,of\,g(.)} \tag{18}$$

where $\tilde{P}_N$ is the relative price of the non-tradable good to the intermediate good a, i.e. $\tilde{P}_N = P_N/q_a$. In the classic Balassa-Samuelson framework movements in the non-tradables' price occur due to differences in factor intensities $(\alpha_T - \alpha_N)$ and sectoral capital-labour shares. Allowing for $\varepsilon < \infty$ provides an additional source of fluctuations in P_N and consequently the real exchange rate. Unfortunately, empirical evidence is not sufficient to justify any particular parametrization of ϵ. However, what our exercise has shown is that if this parameter is determined as a minimum distance estimator between some key theoretical and empirical moments of the real exchange rate, it can be consistent with a negative B-S correlation as well. We stress that this friction in capital markets is important for the quantitative outcomes of the model, but the intuition by which expected shocks lower the consumption-real exchange rate correlation still holds. Even with homogeneous capital, the B-S correlation in news-driven economies is by almost 30 percentage points lower than when shocks are surprises, while being consistent with international co-movements and news-driven expansions.

At this point it is also worth emphasising that a negative correlation in the benchmark economy is the efficient allocation. Given the friction in capital markets, the social optimum is such that much more capital services are allocated to the tradables sector and the B-S correlation is negative. Put differently, consumption being higher where it is more expensive is the price to pay for efficiency in a world where - among other things - capital markets are characterised by the function above. On the other hand, absent any frictions in the financial markets, the social planner chooses a more even distribution of capital which has much lower impact on the marginal product of labour, the wage and finally the price of non-tradables[21].

[21] This intuition shares some similarities with Kocherlakota and Pistaferi (2007) who show that the B-S puzzle can be a result of imperfect functioning of financial markets within, rather than across,

Table 5: Fixed Capacity Model

	Data	Unexpected Shocks	News Shocks
St. Deviation relative to GDP			
Consumption	0.94	0.659	0.588
Investment	4.33	1.974	2.155
Hours	1.19	0.631	0.626
Real Exchange Rate	3.90	0.528	0.516
Terms of Trade	1.68	0.455	0.477
Relative Price of NT	0.86	0.0.931	0.920
Correlation between real GDP and			
Real Net Exports	-0.48	-0.108	-0.101
International co-movements			
Outputs	0.68	0.387	0.358
Consumptions	0.60	0.587	0.457
Hours	0.54	0.397	0.356
Investments	0.25	0.202	0.305
Correlation between RER and			
Rel. Consumption	-0.42[1]	**0.273**	**0.267**
Rel. Output	-0.19	-0.094	-0.085
Terms of Trade	0.52	0.354	0.328
Real NX over GDP	0.60	0.845	0.794

[1]Median of bilateral US dollar real exchange rates across 16 industrialised countries (source: Corsetti et al 2008). The data column was adapted from Corsetti et al (2008). Both empirical and model-generated data are HP-filtered with a smoothing parameter equal to 100. Theoretical moments are asymptotic.

4.4 Variable Capacity Utilisation

Jaimovich and Rebelo (2008, 2009) show that variable capacity utilisation in a small open-economy and a closed-economy set-up can induce economic expansions in response productivity news-shocks. On the other hand, Baxter and Farr (2005) show how utilisation in a two-country, incomplete markets model can help to explain the co-movement problem, while increasing the variability of economic aggregates (see also Burnside and Eichenbaum 1996). We combine both of these findings in our model and show that variable utilisation is an important element for re-producing empirically relevant movements in relative prices as well.

Table 5 presents the quantitative features of a model where utilisation of capital is fixed at the steady-state value, for economies driven by traditional and expected disturbances. The most striking difference to the benchmark case is a sizeable increase in the B-S correlation which now stands as high as 0.273 and where the wealth effect generated by expected shocks causes only a negligible change. Moreover, absent variable capacity utilisation the model fails to generate news-driven expansions as investment, employment and output in both countries fall at the arrival of new information, while consumption increases. Nevertheless, unconditional correlations are positive but slightly weaker than the benchmark case. Finally, we observe a remark-

borders.

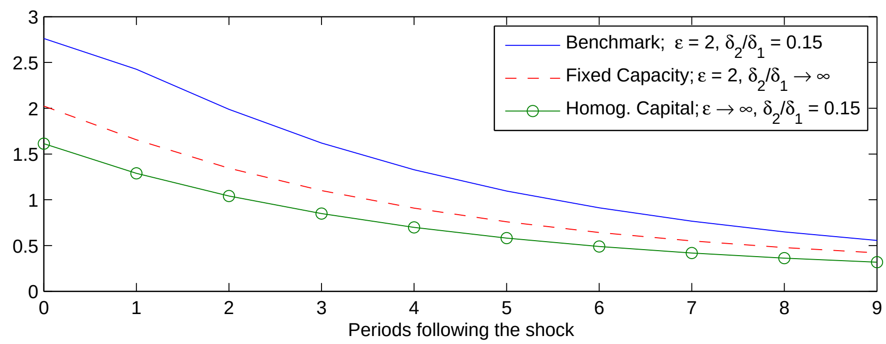

Figure 7: IRFs of the price of non-tradables (P_N) in the benchmark economy (straight line), under fixed capacity (dashed line) and under homogeneous capital (line with circles) to an unexpected shock to the tradables sector in country one. Percentage deviations from steady-state.

able fall in the variability of output (not shown), illustrating the amplification effect of varying capital services (Jaimovich and Rebelo 2009, Burnside and Eichenbaum 1996, Baxter and Farr 2005). This is the main reason why relative volatilities are higher, where a virtue of this model is higher volatility of the real exchange rate to the terms of trade. Figure 7 shows the response of the price of non-tradables in the benchmark economy, one where utilisation is fixed (equivalently, costs of adjusting it are infinite: $\frac{\delta_2}{\delta_1} \to \infty$) and one where capital services are homogeneous ($\epsilon \to \infty$). As it can be seen, both non-homogeneous capital and variable utilisation serve to reinforce the HBS effect; but the former seems more important. Nevertheless, as pointed out variable utilisation is necessary for empirically relevant news-driven business cycles. At the same time, when utilisation is fixed the B-S correlation is never negative. Thus, in the context of our model variable capacity utilisation is necessary for both dimensions that we want to match.

5 Sensitivity Analysis

5.1 Length of news

In this section, we check the sensitivity of our results to varying the length of the arrival of news between zero and five periods, in order to see how the agents allocate the benefits of the wealth effect.

Figure 8 shows that as the length of the interim period increases, not only the B-S correlation grows more negative, but the correlation between the real exchange rate and the terms of trade becomes more positive. News-shocks also contribute to

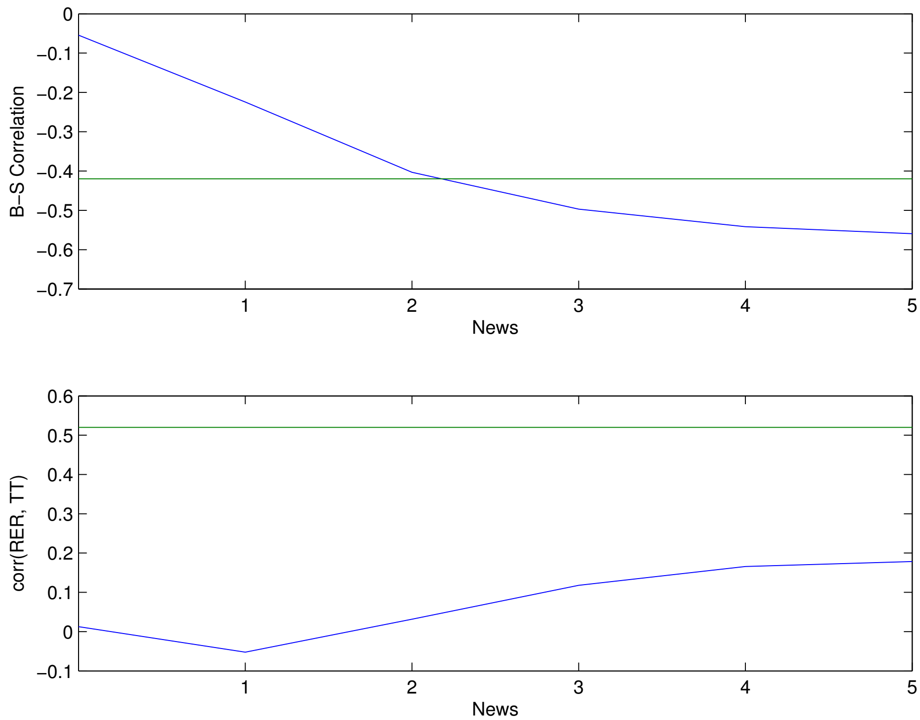

Figure 8: The correlation between the real exchange rate and relative consumption (upper panel) and between the real exchange rate and terms of trade (lower panel) according to the length of the interim period. Horizontal lines show the corresponding empirical statistic.

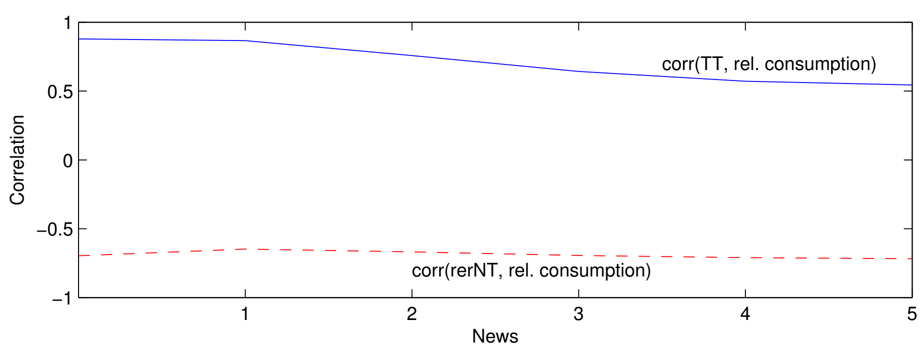

Figure 9: The components of the B-S correlation. Correlation between the terms of trade (TT) and relative consumption (solid line) and between the relative price of non-tradables (rerNT) and relative consumption (dashed line) according to the length of the interim period.

Table 6: Variance of relative prices under different lengths of the interim period

	Real exchange rate	Terms of Trade	Relative price of NT
News			
q=0	0.085	0.241	0.239
q=1	0.131	0.218	0.303
q=2	0.183	0.190	0.369
q=3	0.213	0.173	0.407
q=4	0.227	0.165	0.425
q=5	0.230	0.161	0.430

higher volatility in the relative price of aggregate consumption and the relative price of non-tradables; but to less volatile terms of trade (Table 6).

The improvement of correlations implies that the mechanism behind news-shocks drives both the relative price of tradables and the relative price of non-tradables towards the same direction. Indeed, figure 9 shows that the correlation of relative consumption with respect to both price measures falls for $q > 1$[22]. As we have shown in an earlier part of our work, the terms of trade depreciate by less in response to a news-shock when this refers to a TFP improvement further in the future; and remain pretty stable until the change is materialised (Lambrias 2012)[23]. This behavior is consistent with both less volatile terms of trade and higher real exchange rate - terms of trade correlation. On the other hand, the volatility in the price of non-tradables tends to be higher with expected shocks since these goods cannot be transferred neither across countries nor through time.

5.2 Trade Elasticity

To match the B-S correlation, our model requires a relatively high degree of trade elasticity, but still within the range of values estimated in empirical studies. Figure 10 reports the correlation of the real exchange rate with relative consumption for different values of the trade elasticity of substitution. The correlation falls almost monotonically and for values up to 2.88 it is always lower when shocks are antici-

[22]This fall is most pronounced in the case of the terms of trade. It goes from 0.878 for $q = 0$ to 0.544 for $q = 5$; whereas the correlation between the relative price of non-tradables and relative consumption falls by a mere 2 percentage points.

[23]The reason is because the strength of the wealth effect is lower the longer it takes for technology to improve. At the same time, most of depreciation necessary to clear the market occurs on impact, since no new information arrives in between the signal and the realization. For a detail exposition on the latter mechanism in the context of the BKK model see Lambrias (2012).

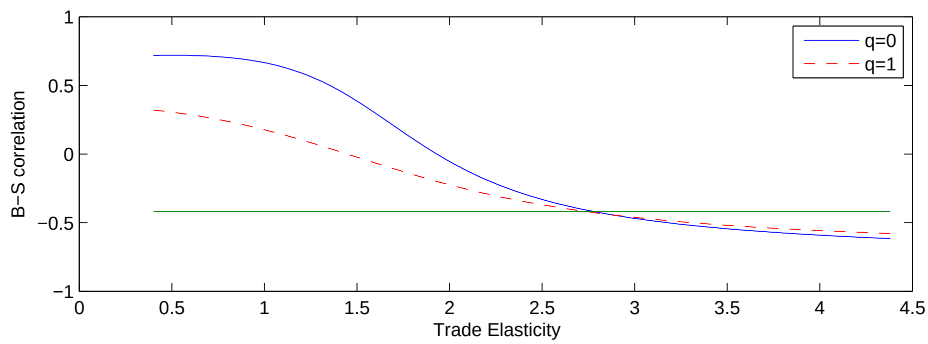

Figure 10: The correlation between the real exchange rate and relative consumption for different values of the trade elasticity of substitution, given unexpected (solid lines) and shocks expected one period in advance (dashed lines). Horizontal lines show the corresponding empirical statistic.

pated. It changes sign at $\theta = 1.94$ and $\theta = 1.46$ for unexpected and expected shocks respectively.

Corsetti, Dedola and Vianni (2011) show that for explanations of the B-S puzzle hinging on the relative price of non-tradables, it must be that output fluctuations are mostly driven by tradables, trade elasticity is high, and the elasticity of substitution between tradables and non-tradables is below one. Indeed, our model satisfies these conditions and their results follow even in a complete-market world[24].

Corsetti et al (2008) show that a low elasticity of substitution can trigger strong wealth effects once the complete-market assumption is relaxed; leading to a negative B-S correlation[25]. On the other hand, a BKK-type of model with complete markets and only tradables is consistent with an appreciation in the terms of trade following a TFP shock for as long as trade-elasticity is high (triggering big increases in domestic absorption via sizable movements in investment)[26]. In an economy like ours with non-tradable goods, the terms of trade always depreciate to ensure a positive transmission of productivity shocks. Nonetheless, our news-driven economy is consistent with a negative B-S correlation for a wide range of reliable values of trade elasticity (1.5-2). Finally, even for values of trade elasticity below one, where the model produces a

[24] Benigno and Thoenissen (2008) impose the same conditions in an incomplete markets model.

[25] Low, and particularly below one, elasticity of substitution is associated with higher volatility of prices across countries (Corsetti et al 2008, Raffo 2010, Heathcote and Perri 2002) and can be instructive about the implications of models under different asset structures (Heathcote and Perri 2002, Cole and Obstfeld 1991).

[26] We replicate the BKK model to show that this is the case for $\theta > 6.5$. Consistently, Enders and Müller (2009) show that the estimated value of trade elasticity in such a model is high, at 3.098. In line with Corsetti et al (2008), their estimated value for the incomplete-market counterpart of this model is 0.230.

Table 7: Zero Adjustment costs to investment

	Data	Unexpected Shocks	$\epsilon = 3$
St. Deviation relative to GDP			
Consumption	0.94	0.582	0.601
Investment	4.33	2.040	1.992
Hours	1.19	0.659	0.669
Real Exchange Rate	3.90	0.110	0.089
Terms of Trade	1.68	0.184	0.184
Relative Price of NT	0.86	0.282	0.211
Correlation between real GDP and			
Real Net Exports	-0.48	-0.504	-0.499
International co-movements			
Outputs	0.68	0.404	0.410
Consumptions	0.60	0.559	0.557
Hours	0.54	0.483	0.484
Investments	0.25	0.297	0.304
Correlation between RER and			
Rel. Consumption	-0.42[1]	**-0.555**	**-0.069**
Rel. Output	-0.19	-0.609	-0.134
Terms of Trade	0.52	-0.316	0.058
Real NX over GDP	0.60	0.706	0.282

[1]Median of bilateral US dollar real exchange rates across 16 industrialised countries (source: Corsetti et al 2008). The data column was adapted from Corsetti et al (2008). Both empirical and model-generated data are HP-filtered with a smoothing parameter equal to 100. Theoretical moments are asymptotic.

strong and positive B-S correlation, allowing shocks to be forecastable decreases its value significantly[27].

5.3 Level of adjustment costs to investment

The lower the adjustment costs to investment, the lower the correlation between the real exchange rate and relative consumption. The intuition has already been discussed above (see also Raffo 2010): a lower value for this parameter is associated to a more responsive investment leading to large shifts in domestic absorption and relative demand. Table 7 gives theoretical moments of an economy where adjusting the flow of investment is costless and shocks are surprises. The B-S correlation is negative and very strong.

This suggests that news-shocks may not be needed as an additional source for a negative B-S correlation. In light of the above, we estimate the elasticity of substitution of capital services in a similar manner as before, assuming that adjusting the flow of investment incurs zero costs. [28]. That gives a value of ϵ equal to three. The

[27]For example, if we set the trade elasticity to 0.425 as estimated in Corsetti et al (2008), news-shocks imply up to a 40 percentage points decrease in the B-S correlation.

[28]Usually, the investment adjustment cost parameter (κ) is chosen in order to match the relative variance of investment - which is between 3-4 times that of output. Since in our model this ratio is just above two even in the absence of investment adjustment costs, we introduce the latter only to

theoretical moments of an economy where shocks are pure surprises, $\epsilon = 3$ and $\kappa = 0$ are given in the last column of Table 7.

The most notable difference is in the B-S correlation, where in this case is only slightly negative at -0.069 compared to -0.224 in the benchmark case with news-shocks. In terms of international co-movements the two models produce very similar results whereas the relative volatility of the real exchange rate is almost the double in the benchmark model[29]. Overall, our model economy with mild investment adjustment costs and expected innovations to TFP can be consistent with a stronger negative B-S correlation, compared to an economy with zero investment adjustment costs and surprise shocks, while generating news-driven booms.

6 Conclusion

We propose a fully flexible, complete-market model of the international business cycle that can be consistent with two major empirical facts: positive cross-country co-movements of economic aggregates and a low correlation between relative consumption and its relative price. We show that the latter is not necessarily connected to market inefficiency and limited risk sharing, rather it can arise as the efficient allocation in an economy where the price of non-tradables plays an important role for real exchange rate determination and there are strong wealth effects generated by expected TFP shocks. The novelty of the paper is to lay down theoretical foundations, in line with Jaimovich and Rebelo (2009), that are consistent with unconditional moments in prices and quantities, but also with news-driven economic expansions.

References

[1] Alquist, R. and Chinn, M., (2002) *Productivity and the Euro-Dollar Exchange Rate Puzzle.* **NBER Working Paper 8824**.

[2] Arellano, C., Bulír, A., Lane, T., Lipschitz, L. (2009) *The dynamic implications of foreign aid and its variability* **Journal of Development Economics**, 88, 87-102.

[3] Backus, D. K., Smith, G., W. (1993) *Consumption and Real Exchange Rates in dynamic economies with non-traded goods.* **Journal of International Economics**, Vol. 35, 297-316.

ensure a positive response of investment to expected shocks.

[29]Indeed, the benchmark model performs better in terms of quadratic deviations of theoretical real exchange rate moments to empirical ones; as well as overall (i.e. all moments in the table).

[4] Backus, D. K., Kehoe, P. J., Kydland, F. E. (1992) *International Business cycles.* **Journal of Political Economy**, Vol. 100, No. 4 (August), 745-775.

[5] Backus, D. K., Kehoe, P. J., Kydland, F. E. (1994) *Dynamics of the Trade Balance and the Terms of Trade: The J-Curve?.* **American Economic Review**, Vol. 84, No. 1 (March), 84-103.

[6] Baxter, M. and Crucini, M. (1995) *Business Cycles and the Asset Structure of Foreign Trade.* **International Economic Review**, Vol. 51, No.4 (November), 821-854.

[7] Baxter, M., Farr D. D. (2005) *Variable Capacity Utlization and International Business Cycles.* **Journal of International Economics**, 65, 335-347.

[8] Beaudry, P., Portier, F (2004). *An exploration into Pigou's theory of cycles.* **Journal of Monetary Economics**, Vol. 51, 1183-1216.

[9] Beaudry, P., Portier, F (2006). *Stock Prices, News and Economic Fluctuations.* **The American Economic Review**, Vol. 66, No. 4 (September), 72-91.

[10] Beaudry, P., Portier, F (2007). *When can changes in expectations cause business cycle fluctuations in neo-classical settings?* **Journal of Economic Theory**, 135, 458-477.

[11] Beaudry, P., Dupaigne, M., Portier, F (2011). *Modelling News-Driven International Business Cycles.* **Review of Economic Dynamics**, 14, 72-91.

[12] Benhabib, J., Rogerson, R., Wright, Randall (1991) *Homework in Macroeconomics: Household Production and Aggregate Fluctuations.* **Journal of Political Economy**, Vol. 99, No. 6 (December), 1166-1187.

[13] Benigno, G., Thoenissen, C. (2008) *Consumption and real exchange rates with incomplete markets and non-traded goods.* **Journal of International Money and Finance**, Vol. 27, 926-948.

[14] Bergstrand, J. H. (1991) *Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence.* **American Economic Review**, Vol. 81(1), 325-334.

[15] Betts, C., Kehoe, T. (2006) *US real exchange rate fluctuations and relative price fluctuations.* **Journal of Monetary Economics**, Vol. 53(7), 1297-1326.

[16] Burnside, C., Eichenbaum, M. (1996) *Factor-Hoarding and the Propagation of Business-Cycle Shocks.* **American Economic Review**, Vol. 86(5), 1154-1174.

[17] Chari, V. V., Kehoe, J. P. and McGrattan, E. R. (2002) *Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?.* **The Review of Economic Studies**, Vol. 69, No. 3 (July), 533-563.

[18] Cole, L. H., Obstfeld, M. (1991) *Commodity trade and international risk sharing. How much do financial markets matter?.* **Journal of Monetary Economics**, Vol. 28, 3-24.

[19] Corsetti, G., Dedola, L., Leduc, S. (2006) *Productivity, External Balance and Exchange Rates: Evidence on the Transmission Mechanism Among G7 Countries.*. **NBER Working Paper** 12483.

[20] Corsetti, G., Dedola, L., Leduc, S. (2008) *International Risk Sharing and the Transmission of Productivity Shocks.* **Review of Economic Studies**, Vol. 75, 443-473.

[21] Corsetti, G., Dedola, L., Vianni, F. (2011) *Traded and Non-Traded Goods Prices and International Risk Sharing: An Empirical Investigation.* **NBER Working Paper No. 17501**.

[22] De Gregorio, J., Wolf, H. C. (1994) *Terms of Trade, Productivity and the Real Exchange Rate.* **NBER Working Paper No. 4807**.

[23] Enders, Z., Müller, G. J. (2009) *On the international transmission of technology shocks.* **Journal of International Economics**, 78, 45-59.

[24] Engel, C. (1999) *Accounting for US Real Exchange Rate Changes.* **Journal of Political Economy**, Vol. 107, No. 3 (June), 507-538.

[25] Engel, C., Rogers, J. H. (1996) *How wide is the border?.* **The American Economic Review**, Vol. 86(5), 1112-1125.

[26] Greenwood, J., Hercowitz, G., Huffman, G. W. (1988) *Investment, Capacity Utilization and the Real Business Cycle.* **American Economic Review**, Vol. 78(3), 402-417.

[27] Heathcote, J. and Perri, F. (2002) *Financial Autarky and International Business Cycles.* **Journal of Monetary Economics**, Vol. 49, 601-627.

[28] Hooper, P., Johnson, K., Marquez, J. (2000) *Trade Elasticities for the G-7 Countries.* **Princeton Studies in International Economics**, No. 87 (August).

[29] Jaimovich, N., Rebelo, S. (2008) *News and Business Cycles in Open Economies.* **Journal of Money, Credit and Banking**, Vol. 40, No. 8.

[30] Jaimovich, N., Rebelo, S. (2009) *Can News about the Future Drive the Business Cycle?.* **American Economic Review**, Vol. 99(4), 1097-1118.

[31] Jaef, R. F. (2011) *Entry, Exit and Misallocation Frictions.* **University of California, Los Angeles**.

[32] Kakkar, V. (2003) *The Relative Price of Nontraded Goods and Sectoral Total Factor Productivity: An Empirical Investigation.* **The Review of Economics and Statistics**, Vol. 85, No. 2 (May), 444-452.

[33] Karabarbounis, L. (2010) *Labor Wedges and Open-Economy Puzzles.* **University of Chicago, Booth School of Business**, October.

[34] Kocherlakota, N., and Pistaferi, L. (2007) *Household Heterogeneity and Real Exchange Rates.* **The Economic Journal**, Vol. 117(March), C1-C25.

[35] Kollmann, R. (1995) *Consumption, Real Exchange Rates and the structure of International Asset Markets.* **Journal of International Money and Finance**, Vol. 14, No. 2, 191-211.

[36] Lambrias, K. (2011) *World Technology Shocks and the Real Euro-Dollar Exchange Rate.* **TSE Working Paper**, No. 11-261

[37] Lambrias, K. (2012) *News Shocks and the Terms of Trade: A Quantitative Investigation*, unpublished manuscript, **Toulouse School of Economics**, https://sites.google.com/site/klambrias/home/research-2.

[38] Mandelman, F. S., Rabanal, P., Rubio-Ramirez, J. F., Vilán, D. (2011) *Investment-specific technology shocks and the international business cycle: An empirical assessment.* **Review of Economic Dynamics**, Vol. 14(1), 136-155.

[39] Mendoza, E. G. (1991) *Real Business Cycles in a Small Open Economy* **American Economic Review**, Vol. 81(4), 797-818.

[40] Mendoza, E. G., Uribe, M. (2000) *Devaluation Risk and the business-cycle implications of exchange-rate management* **Carnegie-Rochester Conference Series on Public Policy**, Vol. 53, 239-296.

[41] Nam, D., Wang, J. (2010)[a] *Understanding the Effect of Productivity Changes on International Relative Prices: The Role of News-Shocks.* **Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute**, Working Paper No. 61, October.

[42] Nam, D., Wang, J. (2010)[b] *The Effects of News About Future Productivity on International Relative Prices: An Empirical Investigation.* **Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute**, Working Paper No. 64, October.

[43] Opazo, L. (2006) *The Backus-Smith Puzzle: The role of Expectations.* **Central Bank of Chile Working Papers**, No. 395, December

[44] Rabanal, P., Rubio-Ramirez, J. P., Tuest, V. (2008) *Cointegrated TFP processes and International Business Cycles.* **Working Paper, La Caixa**.

[45] Raffo, A. (2010) *Technology Shocks: Novel implications for International Business Cycles.* **International Finance Discussion Papers**, No. 992.

[46] Schmitt-Grohé, S., Uribe, M. (2010) *What's News in Business Cycles.* **Columbia University**

[47] Stockman, A., Tesar, L. (1995) *Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements.* **American Economic Review**, Vol. 85(1), 168-185.

7 Appendix

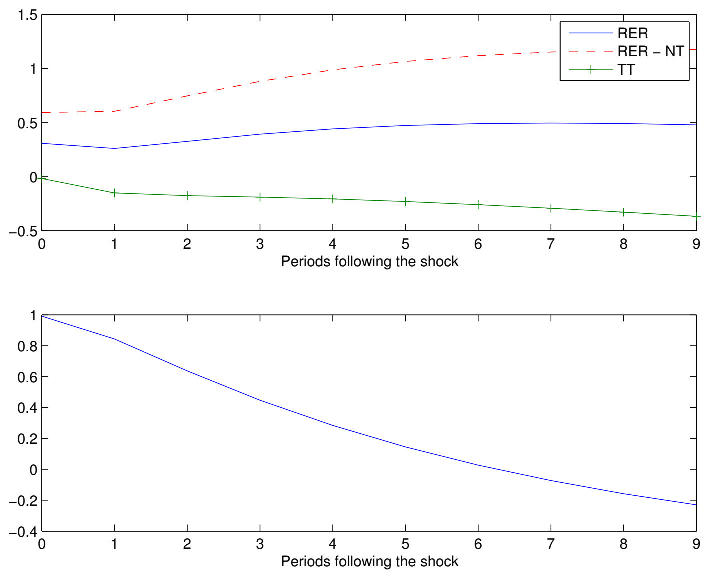

Figure 11: The response of relative prices (upper panel), i.e. the real exchange rate (RER), the terms of trade (TT) and the relative price of non-tradables (RER-NT), and relative consumption (lower panel) to one standard deviation unexpected shock to the non-tradable-goods sector. Percentage deviations from the steady state.

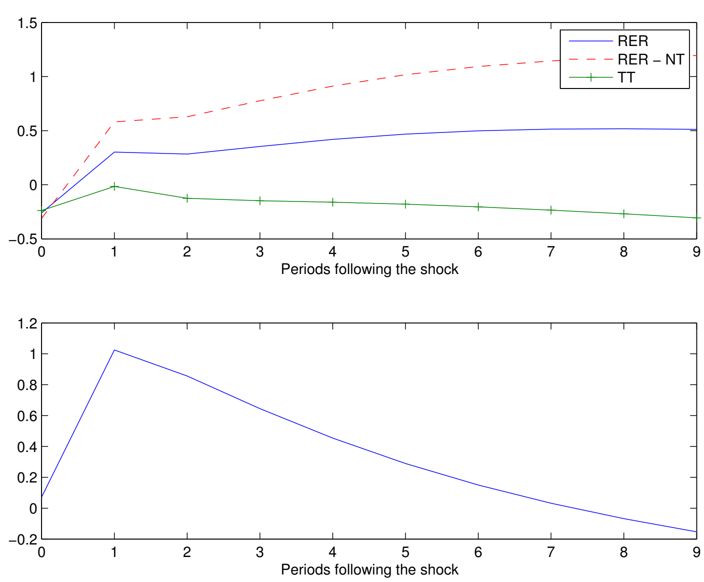

Figure 12: The response of relative prices (upper panel), i.e. the real exchange rate (RER), the terms of trade (TT) and the relative price of non-tradables (RER-NT), and relative consumption (lower panel) to one standard deviation expected shock to the non-tradable-goods sector. Percentage deviations from the steady state.

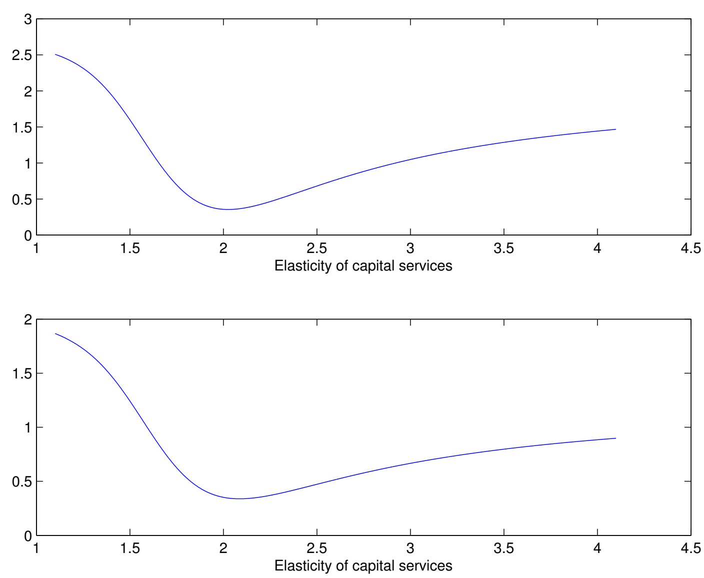

Figure 13: The upper panel shows values of the quadratic loss function in all three moments, i.e. the correlation between the real exchange rate and relative output, terms of trade, and net exports over GDP ratio. The lower panel shows values of this function when taking into account only the last two moments. In both cases, moments are equally weighted and estimations were carried out in economies where shocks are surprises. On the horizontal axis are values of the elasticity of substitution in capital services ε.

BANQUE CENTRALE DU LUXEMBOURG
EUROSYSTÈME

2, boulevard Royal
L-2983 Luxembourg

Tél.: +352 4774-1
Fax: +352 4774 4910

www.bcl.lu • info@bcl.lu