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Abstract

In an open economy environment, the New Keynesian Phillips Curve (NKPC) becomes sensitive to trade dynamics, even more so when applied to emerging economies. The literature incorporates openness to trade by means of a constant domestic bias for local goods over foreign ones. Such an assumption misses out on important dynamics of a small, open emerging economy. We address these shortcomings with several innovations: First, we substitute constant domestic bias with imperfect access to consumption goods for households. Second, we introduce real rigidities, in order to formulate a micro-founded framework for the lack of domestic goods. Consumers in our benchmark small open emerging economy import goods from abroad due to imperfect access to domestic consumption goods. Third, domestic firms cannot satisfy local demand due to low investment in capital units and real adjustment costs.

Our model also examines the welfare effects of monetary policy regimes. We propose an alternative criterion that depends on inflation, domestic firms' markup and openness to trade. We find that autarkic countries are bound to experience the more significant impact of monetary policy, whereas open ones experience smaller changes in real output following an expansive monetary shock.

JEL Codes: *F12, F41, E52.*

Introduction

Since Phillips (1958) came up with the first iteration of the eponymous curve, the economic debate surrounding the Phillips equation has had an impact on its specification. Woodford (2003) presents the form of the New Keynesian Phillips Curve (NKPC) that fits most of its recent versions. It incorporates a forward-looking inflation component within a micro-founded framework. In order to achieve this, the economy is assumed to be populated with a continuum of small firms, specialising each in a single intermediate good. These firms are price-setters, and thus set their production below optimum, using their markup power. The model framework also assumes that firms cannot adjust their prices instantaneously due to random indexations, or real costs attached to price changes. The combination of these two key assumptions establishes a link between inflation - present and expected - on the one hand, and on the other hand, fluctuations of the average marginal cost in the economy. The literature uses wages as a proxy for production costs, and thus considers the output gap as proportional to deviations of the average marginal cost around its competitive, flexible-prices level

The New Keynesian Synthesis also looks at the effects of monetary policy regimes on welfare and real output. Given that production is below its competitive, flexible-prices level, monetary policy is likely to have a real impact on macroeconomic aggregates. The literature compares the effects of various monetary policy regimes on welfare, which is computed in terms of second-order deviations from an efficient steady-state.

When introduced in an open economy environment, the literature uses a constant domestic bias between local and imported goods. The main conclusions of the standard NKPC framework remain valid when incorporated in an open economy. Monetary policy in small open economies can be summarised into a tradeoff facing monetary authorities, between inflation and exchange rate stability.

The literature has made meaningful strides in the last couple of decades in coming up with a micro-founded framework with forward-looking components for the Keynesian theory. Nonetheless, its underlying assumptions run at odds with the particular properties of open, emerging economies. The New Keynesian Synthesis benchmark model runs exclusively on nominal rigidities, which misses out on significant features of short-run macroeconomic fluctuations in emerging economies. Indeed, Garcia-Cicco, Pancrazi & Uribe (2010) fit a standard Real Business Cycles model with real rigidities in order to improve its performance in replicating fluctuations observed in Latin American economies.

We stress below those limitations that stem from the lack of of real rigidities in the framework: the proposed model should be able to replicate macroeconomic fluctuations in emerging economies. In that sense, the literature pioneered in Ball & Romer (1990) and Christiano, Eichenbaum & Evans (2005) has formed a clear-cut consensus that real wedges vastly improve the model's ability to replicate the stylised facts regarding nominal

variables. The New Keynesian Synthesis does a poor job in mimicking those moments, precisely because it does not incorporate real rigidities. In addition, the New Keynesian framework relies on wages as a proxy for the marginal cost. This choice may be explained by the fact that the primary purpose of the Phillips curve was to establish a link between unemployment and inflation *via* the labour market. However, the marginal cost in emerging economies encompasses other aspects that the standard NKPC may miss out. Furthermore, real rigidities generate an inefficient steady-state, whose effects reverberate across the New Keynesian model predictions. Real wedges lower the natural level of output, which means that a model with no real rigidities overstates the output gap. The same bias affects the model's predictions as to the welfare impact of the monetary policy regimes pursued by monetary authorities. The literature frequently measures welfare losses with a second-order approximation around an efficient steady-state, which may lead to overstated welfare gains from a particular set of monetary policies.

In view of the limitations presented above, we contend in this paper that when it comes to emerging economies, the literature's use of the NKPC in an open economy environment misses out on crucial aspects. Indeed, trade between these economies and the rest of the world introduces additional dynamics to the domestic market structure, as well as domestic firms' pricing schedule, which affect the Phillips curve slope. In assuming that households exhibit a constant, parametrised domestic biais in favour of local goods, the literature does not account for strategic interactions between local and imported goods. We argue that there are contradictory effects on inflation: on the one hand, price stickiness increases because domestic firms no longer track their prices to their respective marginal costs, but set them with respect to their foreign competitors. On the other hand, increased competition from imported goods pressures local producers into lowering their prices, thus creating a disinflationary effect.

At the heart of our model lies the mixture of real and nominal rigidities, which provide the micro-foundations for imperfect access to intermediate goods. First, it establishes a direct link between openness to trade and CPI inflation, which features prominently in the new Keynesian Phillips curve. Romer (1993) establishes a link between openness to trade and inflation through issues of pre-commitment on monetary policy. He argues that a large, less open economy has a greater incentive to expand, and thus to settle for a higher equilibrium rate of inflation via a relaxed monetary policy. We propose a similar argument tailored to our model: for a small open economy, we argue that increased openness to trade reduces inflation, a continuation of some of the results put forward in Razin & Yuen (2002). In particular, we argue that openness to trade is driven by production of capital-intensive goods. As the economy integrates with global trade, domestic firms' market power is diluted due to the combined effects of competitive imported goods on the one hand, and consumers' preference for diversity on the other. As a result, CPI inflation

in the domestic economy converges to its global level. Furthermore, competition from imported goods compels domestic firms to increase their output, thus setting aggregate supply close to, or at optimal level.

Second, intermediate firms in our model rely on capital and labour to produce their respective outputs. Because they face real capital costs of adjustment *à la* Hayashi (1982), their aggregate production and investment are below optimal level. Wang & Wen (2012) argue that firm-specific investment is more volatile than aggregate capital accumulation, which is evidence for the existence of installation and adjustment costs at the firm level. These real rigidities translate into a sub-optimal level of capital, and intermediate goods are not as capital-intensive as firms would like to in a frictionless setting. Because openness to trade is increasing in the production of capital-intensive goods, aggregate openness to trade depends on firm-specific costs of adjustment. This illustrates the point made by Ireland (2001) about the relevance of capital stock with regards to interest rates in a new Keynesian model. Imperfect access to consumption goods is therefore directly sensitive to real costs attached to capital accumulation. Inflation and the output gap are indirectly influenced by real rigidities through imperfect openness to trade. In addition, Ball & Romer (1990) argue that real rigidities can significantly improve on a model's ability to replicate price stickiness, even with moderate nominal frictions. Furthermore, Christiano, Eichenbaum & Evans (2005) formulate a model which features prominently capital utilisation and investment adjustment costs, because these real rigidities are able to yield a satisfactory level of persistence in various macroeconomic variables.

Third, the model in this paper proposes alternative definitions of the exchange rate and trade balance variables, in contrast to the literature's reliance on national accounting identities. Instead of defining the exchange rate as pricing foreign goods in terms of domestic goods, we focus instead on the price differential for the same good produced at home and abroad. Similarly, the national accounting-based definition of the trade balance is set aside in favour of an expression that defines trade imbalances as a differential between the actual level of production and investment, *versus* the corresponding variables in a frictionless regime with total trade integration. As we focus on emerging economies, we carry out a decomposition analysis between consumption and investment-driven imbalances. This approach yields a more apropos analysis of the ambiguous effects exogenous shocks have on the trade balance through consumption and investment variables. Capital instalments through foreign investment generate a sustainable deficit in the medium run, since it contributes to accumulate capital goods and increase trade integration. As a result, domestic households rely less on imported goods, thus resulting in a reduction of trade deficits in the long run. By contrast, a deficit mainly driven by consumption imports is unsustainable.

Fourth, the modified new Keynesian framework allows on the one hand for an alternative specification to the tradeoffs facing monetary authorities, and on the other hand,

an enumeration of possible monetary policy instruments, and their respective impacts on welfare. Romer (1993) touches upon monetary policy by arguing that unanticipated monetary expansion generates a depreciation of the real exchange rate. The benefits stemming from such a policy are are offset in increasing openness to trade. We argue that monetary policy effects on real variables weaken with increasing trade integration. As discussed above, openness to trade brings cheaper imported goods that drive down the aggregate price index. In addition, domestic firms are compelled to increase their production, thus setting aggregate supply closer to its optimal level. As a result, monetary expansion effects are decreasing in openness to trade. Welfare outcomes vary with monetary policy regimes, which suggests a welfare analysis is required to show if there is a monetary regime favoured by monetary authorities, and more generally the kind of tradeoffs they face. We use Gali & Monacelli (2005) and Gali (2008) methods to assess the impact of various monetary policy rules on a small open emerging economy. They derive quantitative results for a small open economy, and conclude that all their baseline calibration yields suboptimal outcomes for all proposed alternative policy regimes. They also conclude that a hybrid regime of domestic inflation-targeting and pegged exchange rate yields a better outcome for the economy. We find similar results, though we contend that the literature's use of steady state-based criterion is bound to overestimate welfare losses in an emerging economy, regardless of monetary policy regime. Our welfare analysis shows that the tradeoff between exchange rate volatility and CPI inflation stability the central bank faces is better understood when the effects of trade integration are taken into account. The welfare criterion is computed in the literature following Rotemberg & Woodford (1999) as a second-order deviation from the steady-state. We argue that in our setting, the steady-state is inefficient due to real rigidities, and therefore cannot be used in order to evaluate welfare losses. FollowingLucas (2003), consumers form their choices with respect to a smooth consumption trend, devoid of stationary exogenous shocks. We turn the Lucas argument on its head, and argue instead that the proper welfare criterion should be the consumption level observed in a frictionless Real Business Cycle (RBC) model. Since macroeconomic policy is inefficient in a Walrasian general equilibrium setting, we contend that it makes for a more relevant welfare criterion than the steady-state.

Our paper is outlined as follows: we review in the first section the New Keynesian synthesis and new open economy macroeconomics literatures in order to underline the main properties of our model. The second section compiles a dataset on a large country sample designed to elicit relevant stylised facts regarding inflation and openness to trade. The section provides empirical evidence that capital-intensive manufacture production-driven openness to trade results in lower levels of inflation. Section three introduces a new Keynesian model in which we consider significant alterations with respect to the standard framework. The fourth section is devoted to monetary policy applications, and carries out a welfare analysis on a selected set of monetary policy regimes: CPI and domestic CPI

inflation targeting, as well as a fixed exchange-rate regime and an exchange rate crawl. The fifth section concludes.

1   Literature review

The model in our paper draws upon two strands of macroeconomic literature, defined by a common thread of shared topics. The new Keynesian synthesis devotes a substantial amount of its research on commitment and credibility issues when it deals with monetary policy and its welfare effects. The open economy macroeconomics on the other hand, deals with the impact of macroeconomic policy on trade variables, such as the exchange rate, terms of trade or the trade balance, to name a few. Both incorporate market imperfections and nominal rigidities, as well as focus on inter-temporal substitution and micro-foundations. Another shared aspect is the literature's interest in macroeconomic policy. We review in this section contributions from the literature relevant to our model.

1.1   The New Keynesian Synthesis

The new Keynesian synthesis shares with the new open economy macroeconomics the purpose of formulating a micro-founded framework with strong theoretical foundations. The new Keynesian synthesis focuses on two equations that are a staple of standard Keynesian models, namely the Philips curve, and the IS equation. The new Keynesian literature proceeds in two steps, first in testing its empirical robustness, and second, through a fully-fledged economic model.

The preliminary step is critical in the sense that it uses empirical evidence to justify the relevance of the new Keynesian synthesis. In particular, we look at the results yielded in Fuhrer & Moore (1995) and Fuhrer (1997) for the inflation/output tradeoff, McCallum & Nelson (1999) for an optimising Investment/Savings (IS) equation with a forward-looking component, and Gali & Gertler (1999) in testing for the new Keynesian Phillips curve, with both forward and backward-looking components. In their study of the Phillips curve, Fuhrer & Moore (1995) posit that the backward-looking specification implied by the Taylor (1980) wage-contract model is not consistent with U.S. data. They propose to replace the Taylor-Phelps setting with the following expression:

$$\pi_t = \pi_{t-1} + \gamma y_t \tag{1.1}$$

$$\pi_t = \frac{1}{2}\left(\pi_{t-1} + \mathbb{E}_t \pi_{t+1}\right) + \gamma \hat{y}_t \tag{1.2}$$

Where π, y and $\hat{y}$ refer respectively to inflation, output and its moving average. They also argue that the standard specification fails to replicate empirical inflation persistence,

which they explain by the fact that it does not depend on parameter values and estimation, but rather the way inflation is introduced in the Phillips curve. Fuhrer & Moore (1995) conclude that the data rejects decisively the backward-looking Phillips curve, whereas their estimation results suggest that the hybrid Phillips curve, with both forward and backward-looking inflation component, is statistically more robust. This forward-looking outlook is shared in McCallum & Nelson (1999) whose purpose is to check if the Keynesian model can be fitted within a dynamic, optimising general equilibrium model. They formulate an IS equation with a forward-looking output component, which matches an optimising model. Their proposed model is micro-founded, for agents are defined by their economic functions. That optimising behaviour yields the forward-looking IS equation, which is derived from the log-linearised consumers' Euler equation.

Gali & Gertler (1999) also estimate inflation dynamics in order to check on the validity of the Phillips curve. The authors develop a structural model with a hybrid Phillips curve, *i.e.* one with a backward-looking inflation component. They test the validity of the Phillips curve as a convex combination of future and past inflation, which writes thus:

$$\pi_t = \delta x_t + (1 - \varphi)\mathbb{E}_t \pi_{t+1} + \varphi \pi_{t-1} \tag{1.3}$$

Where $0 < \varphi < 1$ refers to past inflation persistence. Gali & Gertler (1999) then test for de-trended output as a proxy for the marginal cost, but find their estimation result not to be statistically significant. By contrast, when they use average real wages as a proxy for marginal costs, their estimation results are more robust, and they conclude that real marginal costs are a significant inflation driver, a conclusion that is similar to that in Fuhrer & Moore (1995). The Gali-Gertler estimation strategy focuses on parameters in the hybrid new Phillips Curve, and finds its estimation results to be robust to wages as a proxy for real marginal costs. As a result, they conclude that from agents' perspective, inflation can described as the expected flow of discounted future real marginal costs. This review of econometric specifications shows that the new Keynesian synthesis has satisfied the requirement for the Phillips curve and IS equation to be empirically sound. The next step was to devise a micro-founded general equilibrium model to accommodate these results.

As mentioned before, the way to introduce nominal rigidities in a general equilibrium model is to do away with the assumption that markets operate in a competitive setting. Instead, the model assumes that the economy is made up of a continuum of small, intermediate firms, each with market power over its product. The large number of firms insures imperfect substitution of goods, whereas localised market power allows them to be price-setters. Firms with market power set their prices at a markup, and their aggregate supply is below its competitive, optimal level. Ball & Romer (1990) argue that real rigidities are not sufficient to generate nominal price stickiness. The literature offers a plethora

of explanations in order to account for rigidity in nominal wages and prices. Even as real rigidities are incorporated, without explicit sources of nominal stickiness, prices still adjust instantaneously, in contradiction with the Keynesian hypothesis of fixed, or rigid prices. As a result, nominal rigidities are introduced by means of price adjustment costs à

5   la Rotemberg (1982), or by partial price indexation, per Calvo (1983). Ball & Romer argue however that a combination of real and nominal frictions can yield the desired effects from non-neutral money and monetary policy. Clarida, Gali & Gertler (1999) formulate a baseline framework for monetary policy analysis with a forward-looking IS equation and the new Keynesian Phillips curve, which write respectively:

$$x_t = \mathbb{E}_t x_{t+1} - \varphi \left(i_t - \mathbb{E}_t \pi_{t+1} \right) + g_t \tag{1.4}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \lambda x_t + u_t \tag{1.5}$$

10   Where g_t and u_t are exogenous, stationary shocks. The forward-looking IS equation uses the log-linearised Euler equation yielded from the consumers' inter-temporal optimisation problem. The new Keynesian Phillips curve (NKPC) is derived from staggered nominal Calvo price-setting, where a fraction of domestic firms update their prices at random.

15   The new Keynesian model need therefore to be defined beyond its Phillips-IS framework. The Keynesian workhorse is built around the IS-NKPC set of equations, and the new Keynesian synthesis, such as the Clarida & al (1999) deals with monetary policy regimes and their respective impacts on aggregate welfare. A more comprehensive setting has been offered in Christiano, Eichenbaum & Evans (2005), where nominal rigidities

20   are incorporated in order to replicate observed persistence in inflation and output. The model incorporates Calvo price- and wage-setting, habit-formation, adjustment costs in investment, working capital and capital utilisation. The Christiano & al. (2005) model blends in nominal and real rigidities in order to account for, and estimate fluctuations of macroeconomic variables in the United States. Their results give credence to the Ball-

25   Romer argument, namely that real rigidities alone cannot account for price stickiness, whereas a small measure of nominal price stickiness can generate result such that monetary policy has an impact on real variables. Christiano & emphal. also introduce real rigidities because these improve on their model's ability to replicate stylised facts.

Given that our paper deals with a small open emerging economy, we also look at new

30   Keynesian literature that deals with nominal rigidities in an open economy environment. Razin & Yuen (2002) extend the standard closed-economy Phillips curve to an open economy with trade and capital mobility. They conclude that opening an economy to trade flattens the Phillips curve, and thus weaken the inflation-output gap tradeoff it describes. Gali & Monacelli (2005) take the new Keynesian workhorse model to a small

open economy, and articulate issues. They offer a tractable framework designed to assess the effects of monetary policy on welfare and volatility of exchange rate and terms of trade. Though they conclude that their model is nearly identical to the closed economy standard new Keynesian model, they point out that variable equilibrium conditions are sensitive to the small open economy's openness to trade, as well as substitutability between domestic and foreign goods. Their results show policymakers in small open economies are faced with a tradeoff between welfare targets and exchange rate stability. For instance, a policy of strict domestic CPI inflation targeting on behalf of monetary authorities yields significant volatility in nominal exchange rate as well as terms of trade. On the other hand, the focus on domestic inflation, rather than a broad-based CPI inflation as defined in a Taylor monetary rule is shown to generates superior welfare benefits.

The Gali-Monacelli framework has markedly improved upon the Obstfeld-Rogoff framework in the literature on open economy macroeconomics, but misses out on three aspects. First, their model borrows heavily from the new Keynesian workhorse, where output is entirely consumed, and there are no capital markets. Ireland (2001) argues that the inclusion of physical capital with adjunct costs of adjustment improve on the model's ability to replicate the behaviour of interest rates. Christiano, Trabandt & Walentin (2011) discuss the issue where an increase in nominal rates may paradoxically boost inflation if borrowing constraints are included in the model, such as working capital. In that case, intermediate firms face a higher wage bill when interest rates go up, and then pass on the subsequent increase in marginal costs to their prices, thus boosting inflation. Second, it is doubtful labour costs are a pertinent proxy for real marginal costs in emerging economies, where imperfect market structures are prevalent. Woodford (2005) argues that when the new Keynesian model takes into account firm-specific capital, then the predicted slope of the Phillips curve for inflation to the output gap changes dramatically, reflecting the fact that firms engage in strategic interactions within the capita rental market. These changes are echoed in a similar argument made in Christiano & al (2011). Third, the Gali-Monacelli model assumes a constant degree of home bias in consumption preferences for households. Rumler (2007) tests the Phillips curve for a set of relatively small open economies in the Euro area. He concludes that open economies tend to adjust their prices more frequently, which is in line with the model's predictions. A similar exercise is carried out in Mihailov, Rumler & Scharler (2011) the parameter that denotes home bias is found not to be statistically significant for many in the country sample, and regardless of the proposed econometric specification. Home bias needs therefore to be endogenous within the proposed open economy new Keynesian framework. Watson (2016) proposes a model where increased openness to trade generates two distinct and contradictory effects on inflation: on the one hand, increased trade integration raises strategic complementarity between domestic firms, so they are less likely to pass on shocks to their marginal costs, thus raising price stickiness. On the other hand, increased product diversity dilutes

their market power, and firms need to adjust their prices more frequently, an assumption backed up by available data.

1.2   The New Open Economy Macroeconomics

Obstfeld & Rogoff (1995) argue that the literature on open macroeconomics suffered
5   hitherto from inherent contradictions: the mainstream models derived from the Mundell-Fleming (1962,1968) consisted of an economy system of two markets, one for domestic output, and the other for foreign trade. It sought to describe transmission mechanisms of macroeconomic policies by means of national account identities. Although it was empirically robust and was widely used by policymakers, it did not have a strong theoretical
10   background. Frenkel & Razin (1987) comprehensively enumerate the Mundell-Fleming model limitations. First, its reliance on national accounting means that the model lacked clear micro-foundations, as it did not provide an explicit definition of agents economic behaviour. Second, the lack of inter-temporal resources constraints greatly limits the model's dynamic scope. Third, the very absence of inter temporal decision-making sched-
15   ule precludes forward-looking agent decision rules, and limits further the model's ability to provide predictions in the short and medium run. Fourth, as reported in Obstfeld & Rogoff (1995) the Mundell-Fleming is mainly demand-driven, and makes no provisions for a supply-side definition of aggregate production, further underlining its lack of micro-foundations..

20   On the other side of the literature, inter-temporal models have been devised on sound theoretical bases, yet make little room for macroeconomic policy analysis. The standard Walrasian general equilibrium model in an open economy is the International Real Business Cycle (IRBC) model inaugurated in Backus, Kehoe & Kydland (1992). Their paper extends the standard Real Business Cycle (RBC) framework to a multi-country set-
25   ting. They formulate their model in order to account for co-movements between output and household consumption as observed among OECD economies. Their extended IRBC model is predicated on the assumption that observed fluctuations are the results of agents' optimal responses to unexpected, exogenous shocks. Their model predicts high correlation between consumption and output among their selected country sample. Backus &
30   al conclude to the need for explicit trading fractions in order to improve on the model's ability to replicate co-movements and global trade. A similar conclusion is shared in Mendoza (1991) whose RBC model is applied to Canada as a proxy for a small open economy. Backus & al (1992) omit however to discuss issues of macroeconomic policies and their effects on trade flows. While the RBC framework is a state-of-the-art inter-temporal model,
35   one should keep in mind that it is a Walrasian model of general equilibrium. As such, it describes agents' optimal reaction to exogenous, stochastic shocks. This means that any cycle-smoothing policy is likely to yield low or no welfare gains, whereas macroeconomic

variables at Pareto-optimal cannot be improved upon by government policy. As a result, applications of macroeconomic policies are limited. Furthermore, the BRC framework posits that fluctuations are mainly driven by real factors, such as productivity shocks. Coupled with its Walrasian general equilibrium description, it limits greatly its scope and relevance for the study of global trade flows.

Thus the state of inherent contradiction in open economy macroeconomics: on the one hand empirically robust models that lack micro-foundations, and on the other and theoretical models failling to incorporate macroeconomic policy effects on foreign trade exchange. From this contradiction arises the necessity to conciliate between two requirements: on the one hand, the proposed model has to be consistent and based on sound, micro-founded and theoretical bases. On the other hand, it has to produce relevant economic policy analysis and account for the stylised facts displayed by a comprehensive set of variables.

With Obstfeld & Rogoff (2000) the new mainstream in the literature on open economy macroeconomics is established as a synthesis of the inter-temporal approach and price stickiness. In order to achieve this blend between empirical relevance and theoretical consistency, Lane (2001) points out that imperfect competition is a key component in the new open economy macroeconomics literature. Imperfect market structures, such as imperfect competition, bestow some market power on producers, which are thus explicitly defined by their pricing schedule. On the other side, consumers have imperfect elasticity of substitution for available goods. As a result, the combination of monopolistic competition and price sluggishness is achieved within a sound micro-founded framework. Consequently, the new mainstream model is built using monopolistic competition *à la* Blanchard & Kiyotaki (1987) and make use of the Dixit & Stiglitz (1977) consumption index.

There is another purpose to the use of monopolistic competition, one that is more to the point of macroeconomic policy that the new open economy macroeconomics literature seeks to describe within a micro-founded setting. When firms are endowed with market power, they set their prices at a markup, above their marginal cost. As a result, supply is below its competitive level, and government intervention becomes desirable, since it can improve on actual level of output, with the proviso that prices do not adjust instantaneously. Furthermore, price sluggishness insures the consumer's money balance affects their real demand, which opens the way to monetary policy having real and persistent effects on output. In order to achieve price sluggishness, the Obstfeld-Rogoff model further assumes that prices are set in advance. In the face of an unexpected monetary shock, domestic output and consumption increase. The new mainstream allows therefore for macroeconomic policy analysis to be embedded in the inter-temporal framework.

Though it has made significant strides in formulating a new open economy macroeco-

nomic framework, the model presented in Obstfeld & Rogoff (1995, 2000) does not provide a more exhaustive argument in explaining why domestic firms set their prices in advance. The model also assumes that purchasing power parity always holds, and consumption-based exchange rate is constant. Such assumptions do not hold in an open economy environment. These shortcomings generate two major limitations in the Obstfeld-Rogoff framework: first, one-period advanced price-setting does not compute well with the inter-temporal approach, as agents' optimisation schedule create expected variable paths. Second, price dynamics need to be defined in a more exhaustive setting, for instance Rotemberg (1982), whose mechanism describes firms facing real costs of price adjustment, or Calvo (1983) where a fraction of intermediate firms update their prices randomly. Vègh (2013) argues that households' consumption path is sensitive, among others, relative consumption goods prices. As a result, constant consumption-based exchange rate is neither a realistic nor consistent assumption. Households adjust their consumption paths on the basis of expected relative prices, which is where comprehensive price adjustment mechanisms are critical to the model's overall consistency. The focus on path variable with respect to the selected price adjustment mechanism is key to the new open economy macroeconomics. Lim & McNelis (2008) argue that a pure forward-looking model within the new Keynesian model can allow for a greater scope in analysis the impact of macroeconomic policy in an open economy environment. Kollman (2001) develops a model that fits the Obstfeld-Rogoff framework, where prices and wages are staggered and set *à la* Calvo (1983). The model predicts a domestic money supply shock would decrease interest rates, generate a depreciation in the exchange rate and increase domestic output.

To sum up, the Obstfeld-Rogoff framework has defined the new open economy macroeconomics paradigm by blending inter-temporal optimisation models with fixed prices. The use of monopolistic competition and price sluggishness blends well with the tenets of the new Keynesian synthesis. Both strands of the literature assume domestic firms become price-setters. In addition, price sluggishness is introduced by assuming randomness (Calvo (1983)) or price adjustment costs (Rotemberg (1982)). As a result, output is set below its competitive level, and the combined effects give room to macroeconomic policy effects. Market imperfection and price sluggishness are two major contributions of the new Keynesian research programme. The new open economy macroeconomics extends the neo-Keynesian synthesis to an open economy environment.

2   Cross-country evidence

The crux of the argument laid out in this paper is that emerging economies experience lower inflation as they integrate in global trade. Integration is achieved through production, consumption and/or export of capital-intensive goods, particularly manufacturing. In order to provide empirical evidence for that claim, we follow Romer (1993) as he set out

to test his prediction that inflation is higher in countries that produce a greater fraction of their consumption goods, *i.e.* less opened to trade than expected. Our claims are broader and go beyond the issues of pre-commitment in monetary policy. Indeed, we focus on the effects of imported goods on domestic prices, and the indirect effect of capital utilisation on consumption goods. We set out to test for the following predictions: first, according to our predictions, the coefficients that tie inflation to the selected proxies for openness to trade should be negative. Second, using real GDP per capita as a proxy variable, larger economies will experience lower inflation. Third, whether for domestic consumption or exports, countries with a large manufacturing sector experience lower inflation, thanks to their capital-intensive component. Fourth, it is expected to find a tradeoff stability between the exchange rate and inflation, as measured by their respective standard deviations. This last prediction gives an insight into the kind of issues monetary authorities need to deal with in an open economy environment.

2.1 Country sample, specifications and results

We use data from the World Bank (WDI) dataset and the University of Pennsylvania (PWT) database to collect a comprehensive set of indicators that span a period between 1960 and 2014, for a large sample of 180 countries, up from the 114-odd country sample Romer (1993) uses. The country sample is organised into country groups, first the OECD benchmark, and then the rest in their respective geographical groupings: Sub-Sahara Africa, Middle-East & North Africa, South-East Asia, Latin America & Caribbean and Eurasian countries. Given the fact that some of these economies experienced - or still experience- high levels of inflation, it is likely they would influence greatly regression results, regardless of specification. We therefore use a logarithmic transformation on median inflation, so as to reduce the disproportionate effects they may have on regression results. We compare regression results to check whether the use of median or average logged GDP deflator significantly alters the estimated coefficients.

Figure 1 plots import shares of GDP against logged median GDP deflator for the country sample, and identifies country groups. it shows that there is a broadly negative relationship between openness to trade and inflation, and replicate results reported by the literature. Although the slope is negative in both cases, our sample does not yield a statistically significant estimate. The discrepancy in results can be accounted for by the fact that our sample size in time period and the number of countries is larger. It incorporates the steady decline in inflation over the 1990s that has been common to many economies. This can be illustrated by the point estimate of a median inflation of 7% for a closed economy and 5% for imports making up 75% of GDP. These point estimates are to be compared against those obtained by Romer for 18% and 8%, respectively.

We extend the estimated relationship between inflation and openness to trade by
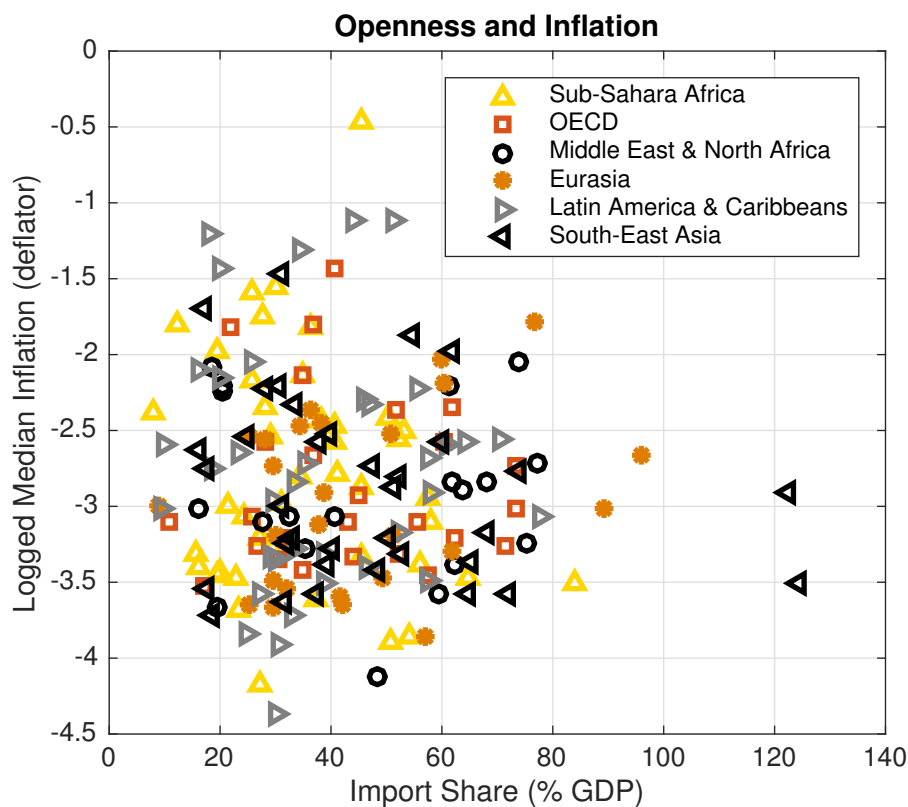
Figure 1: Scatterplot of imports as a share of GDP and logged GDP deflator: 1960-2014.

controlling for factors relevant to the model presented in the third section. Namely, we look at the impact of capital utilisation and manufacturing to test for the working hypothesis of our model. The first specification introduces real income per capita in order to control for the size of the economy. We use a different argument than that
5 presented in Romer: large economies are well integrated, and trade in capital-intensive goods. Furthermore, larger economies have a stronger institutional framework, one that would place a premium on low inflation, as pointed out in Cukierman, Webb & Neyapti (1992). Those economies tend to be more stable, with a resilient institutional framework, and are therefore more likely to experience a weaker link between openness and inflation.
10 Table 1 reports regression results for the GDP deflator as a median and average, over log GDP per capita as a measure for income, and import shares of GDP as a proxy for openness to trade. Estimation results (1) and (3) used average logged GDP deflator, while (2) and (4) used logged median GDP deflator inflation. Regional dummies have been included to check whether region-specific factors can contribute to the relationship
15 between inflation and openness to trade.

Estimation results are consistent with regards to the impact of imports on inflation: the estimated coefficient displays the proper sign, although all results reported in table 1 show the coefficients not to be statistically significant. We also show that real income

per capita is a good proxy for large economies, and that they experience lower inflation under specifications (2) and (4) *i.e.* using median inflation as the endogenous variable. For those specifications that used regional dummies, we show that Latin American & Caribbean, Sub-Sahara Africa and Eurasian economies experience higher inflation rates at a statistically significant level.

Table 1: Estimation results: GDP deflator comparison

Variable	(1)	(2)	(3)	(4)
Log GDP Per Capita	0.045	-0.166***	0.021	-0.160***
	(0.048)	(0.025)	(0.052)	(0.024)
Import Shares	-0.003	-0.001	-0.004	-0.002
	(0.004)	(0.002)	(0.004)	(0.002)
Intercept	-3.002***	-1.394***	-2.264***	-1.460***
	(0.481)	(0.268)	(0.484)	(0.229)
Regional dummies?	Yes	Yes	No	No
R^2	0.201	0.161	0.006	0.142
Log-Likelihood	-253.661	-168.546	-272.504	-170.517
RMSE	1.083	0.631	1.190	0.629
Fisher F	4.196	6.153	0.552	21.501
Sample	172	180	172	180

Standard errors are in parentheses. The dependent variables are logged median and average inflation (GDP deflator). Regional dummies are indicator variables for OECD, Latin America & Caribbean, MENA and Eurasia.
legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

The results reported above confirm that larger economies experience lower inflation, but there is no conclusive proof that openness to trade is indeed linked to lower inflation as well. That is due to the fact that import share is too broad a measure to capture the effects relevant to our model. The primary objective of the dataset is to show that countries well integrated in global trade experience lower inflation through the production of capital-intensive goods. Imports share incorporates a variety of goods, which may weaken the significance of estimated parameters reported in table 1. To that effect, we use three alternative measures for openness to trade that are more likely to captured the desired effects. In addition to the broader measure of openness to trade which incorporates imports as well as exports, we also focus on manufactured goods and their trade flows in the country sample. We argue that they represent a more pertinent indicator to the kind of openness to trade the model deals with in this paper.

Table 2 reports regression results for logged inflation over real income per capita, and we use a much broader definition of openness to trade. In addition to controlling for the sum of exports and imports over GDP, we also control for export and import manufacturing, as well as capital stock. Column (1) regresses logged inflation over real income

and openness to trade, while column (2) controls for trade flows in manufactured goods (exports and imports). Columns (3) and (4) control simultaneously for the manufacturing sector share in GDP and the capital stock. All but column (4) control for region dummies, in order to check on potential region-specific factors.

Table 2: Estimation results: Alternative measures to openness to trade

Variable	(1)	(2)	(3)	(4)
Real Income Per Capita	0.024	0.017	0.039	-0.018
	(0.052)	(0.054)	(0.059)	(0.065)
Openness to trade	-0.006***	-0.005***	-0.001	-0.0001
	(0.002)	(0.001)	(0.002)	(0.002)
Imported Manufacturing		-0.017*	-0.072*	-0.082**
(% Imports)		(0.008)	(0.028)	(0.029)
Exported Manufacturing		-0.009***	-0.014***	-0.017***
(% Exports)		(0.003)	(0.004)	(0.004)
Manufacturing times			-0.003**	-0.003**
Capital Stock			(0.001)	(0.001)
Intercept	-2.478***	-3.015**	-2.521*	-0.512
	(0.518)	(0.907)	(1.117)	(1.245)
Region Dummies included?	Yes	Yes	Yes	No
R2	0.288	0.367	0.429	0.142
Log-Likelihood	-266.850	-245.138	-204.515	-235.339
RMSE	1.063	1.003	0.973	1.173
Fisher F	8.336	10.407	11.012	7.505
Sample	183	176	151	151

See notes on table 1. The dependent variable is logged average inflation.
legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

5

As shown on table 2 the alternative measures for openness to trade incorporate exports as well as flows of manufactured goods perform markedly better. We obtain statistically significant coefficients that line up with the assumption made earlier about manufactured goods. Countries that trade more in those goods, whether for import or export, experience

10 lower inflation. Results from table 2 offer a *prima facie* case for the working hypothesis of the model presented in this paper. Namely, that openness to trade should not just be measured as the size of imports in an economy, but also take into account use of capital. The use of manufacturing as a proxy for such a production turns out to yield statistically robust results. We also find that at least one region exhibits higher than

15 average inflation: countries gathered in the Eurasian country group. Columns (1) and (2) report three region groups with statistically significant higher inflation, namely Eurasia, Sub-Sahara Africa and Latin America & Caribbean, whereas column (4) flags only the Eurasian groups as statistically significant outlier group.

The main takeaway from this section is that openness to trade can reduce inflation under specific conditions. The set of regressions run over a large country sample of developed and emerging economies show that countries that trade most in capital-intensive goods, such as manufacturing, experience lower inflation. Most regression results reported in tables 1 and 2 show that there are few country groups with statistically significant region-specific factors. Those can be discounted by the fact that their excess inflation is generated by factors not captured by the proposed specifications. We conclude that the empirical link between openness to trade *via* intensive goods, and inflation is robust, and buttress the working assumption of our model.

3 The Model

In this model, we propose to expand the new Keynesian framework to an open economy setting, where the Phillips curve equation incorporates explicitly openness to trade. We argue that the inflation/output gap dynamics are sensitive to trade and related exogenous shocks in a small open emerging economy. In order to do so, we alter the new Keynesian model workhorse by including two key components: we substitute the literature's use of a constant domestic biais with the concept of imperfect access to consumption goods. In addition, we make no distinction between domestic and foreign goods, in order to underline the effects of strategic interactions between the two firm types.

The model describes a small open emerging economy where firms face real and nominal costs when they open up to global trade. We make use of the literature's assumption of imperfect markets and price sluggishness, to which we add real costs of adjustment to capital accumulation.

Real rigidities play a significant role in our model for two main reasons. The first is the theoretical argument has been laid out in Ball & Romer (1990). They show that a new Keynesian model improves its ability to replicate stylised facts when it incorporates real wedges as well as nominal rigidities. The second argument is mainly empirical, and deals with the model's ability to replicate empirical moments. It is the consensus of the literature that business cycles are more volatile in emerging economies, as compared against those observed for developed ones. It can be argued that these differences in fluctuations can be attributed to imperfect market structures in the former, which may take the form of real rigidities and inefficient steady-states. In laying out the properties of business cycles in emerging economies, Garcia-Cicco, Pancrazi & Uribe (2010) argue that inefficiencies need to be incorporated in the model framework in order to match these countries' stylised facts. A similar argument is put forward in Schmitt-Grohé & Uribe (2017) where real rigidities exacerbate fluctuations, thus improving the model's ability to replicate observed stylised facts.

3.1 Firms

We describe in this sub-section the properties of private domestic firms in the benchmark economy. Our paper is modelled after the new Keynesian framework as presented in Ireland (2001, 2004) and Gali & Monacelli (2005). The production sector is made up of a continuum of small, intermediate firms. Each one produces a specific output denoted $C_t(i)$, and exerts monopolistic market power over its pricing. Each intermediate firm combines productivity, labour and capital in a Cobb-Douglas production function, which writes:

$$C_t(i) = Z_t N_t(i)^{1-\alpha} \tilde{K}_{t-1}(i)^{\alpha} \tag{3.1}$$

$$\tilde{K}_{t-1}(i) = \upsilon_t(i) K_{t-1}(i) \tag{3.2}$$

Where $\tilde{K}(i)$ refers to the effective level of utilised capital, and $\upsilon_t(i)$ refers to firm-specific capital capacity utilisation. This addition introduces more variability in capital accumulation, and thus has an impact on the firm's cost structure. At the aggregate level, more variable capital, coupled with costs of adjustment, is bound to delay the firms' price adjustments. Furthermore, it makes domestic firms more sensitive to monetary policy shocks. In particular, it allows for an inflationary response to monetary tightening, a case discussed in Christiano & al (2011).

In contrast to the literature, and the Gali-Monacelli in particular, we assume that domestic firms can produce all available intermediate goods in the global market. That is, we do not make an explicit distinction between domestic and foreign goods, only between the fully produced at home, and incomplete ones. Domestic firms are constrained the quantities they wish to put on the market, so they produce a portion of their respective intermediate good, where $\mu_t(i)$ denotes the fraction produced. A small value for $\mu_t(i)$ means that good i is not fully produced at home, and therefore has to be imported by households. In our model, the domestic bias is the consequence of various costs and constraints imposed upon domestic firms. As a result, their optimal production schedule may fall short of households' demand, hence their imperfect access to consumption goods. As a result, households bundle imperfect quantities of intermediate goods, which are then consolidated in a Dixit-Stiglitz (1977) consumption index, which writes:

$$C_t = \left[\int_0^1 C_t(i)^{\dfrac{\mu_t(i)(\theta_t - 1)}{\theta_t}} \, \mathrm{d}i \right]^{\dfrac{\theta_t}{\theta_t - 1}} \tag{3.3}$$

θ_t refers to a time-varying elasticity of substitution between intermediate goods. The Dixit-Stiglitz setting allows for imperfect substitution of intermediate goods, which gives

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market power to producers, who can in turn set their prices at a markup. For $\lim \mu_t(i) \to 0$ Intermediate good i is unavailable on the domestic market, and households need to fully import it. Consumers therefore seek to minimise the gap between the nominal cost of their bundle, and the sum of their intermediate purchases, weighted by each product's openness to trade, or $\mu_t(i)$. The optimisation problem yields intermediate demand, and writes thus

$$\min_{C_t(i)} P_t C_t - \int_0^1 \mu_t(i) P_t(i) C_t(i) \mathrm{d}i \tag{3.4}$$

$$C_t(i) = \left[\frac{P_t(i)}{P_t} \right]^{\frac{-\theta_t}{\theta_t - (\theta_t - 1)\mu_t(i)}} C_t^{\frac{1}{\theta_t - (\theta_t - 1)\mu_t(i)}} \tag{3.5}$$

Where $P_t(i)$ and P_t refer respectively to intermediate and index prices. Note that when the intermediate product is fully produced at home, then $\mu_t(i) = 1$. Intermediate demand reverts to its standard form in new Keynesian literature. Our model writes intermediate demand as a function of imperfect access to consumption goods as well as elasticity of substitution and index prices. Given each firm's individual profit-making schedule, optimal pricing under flexible pricing writes:

$$\max_{C_t(i)} D_t(i) = P_t(i) C_t(i) - TC_t(i) \tag{3.6}$$

$$P_t(i) = \frac{\theta_t}{\mu_t(i)(\theta_t - 1)} MC_t(i) \tag{3.7}$$

Where $TC(i)$ and $MC(i)$ refer respectively to the total and marginal costs. The pricing rule captured by equation (3.7) shows that intermediate firms with market power set their prices above their marginal cost, at a markup that is function of consumers' elasticity of substitution θ_t. When $\mu_t(i) < 1$, the domestic price charges a higher price than the trivial case of $\mu_t(i) = 1$, i.e. the standard pricing rule under price flexibility regime in the new Keynesian model. The extreme example of $\lim_{\mu_t(i) \Rightarrow 0} P_t(i) = \infty$ illustrates our point: such scarce goods would command high prices, through the combination of high production costs, and consumers' preference for diversity.

On the demand side, consumers value diversity through their Dixit-Stiglitz index, including new goods. Their demand for scarce goods is bound to be high, as it increases their overall elasticity of substitution, and thus drives down the aggregate price index. In an autarkic economy therefore, imperfect access to consumption goods exacerbates domestic firms' market power, and reduces elasticity of substitution.

On the supply side, domestic firms cannot produce their output at will as they face real

costs of adjustment to their production and investment schedule. As a result, they that do not invest enough find themselves with an expensive product on the domestic market. This scarcity in domestic consumption goods is due to real costs incurred by intermediate firms in their investment schedule. Profit-making for domestic firms is subsequently affected by

5 two dynamics: first, their own production technology is constrained by real costs, which means that their own production is sub-optimal to their maximising value criterion. It means that they produce less capital-intensive goods than elsewhere in the rest of the world. Second, the arrival of imported goods generates a competitive effect compounded by consumers' elasticity of substitution as well as preference for diversity. The following

10 sub-section explains how firms find themselves producing at sub-optimal levels their own intermediate goods.

3.2 Investment

Each domestic firm seeks to maximise its lifetime value, subject to capital accumulation law of motion, and real costs of adjustments. We adapt the Hayashi (1982) framework so

15 as to introduce explicitly real costs of adjustment for openness to trade. The optimisation programme writes thus:

$$\max \mathbb{V} : \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(D_t(i) - I_t(i) - \varphi_t(K, I) - \varphi_t(\mu, I) \right) \tag{3.8}$$

$$K_t(i) = (1 - \delta_t(i)) K_{t-1}(i) + I_t(i) \tag{3.9}$$

Where:

$$\varphi_t(K, I) = \frac{\phi_k}{2} \left[\frac{I_t(i)}{K_{t-1}(i)} - \delta_t(i) \right]^2 K_{t-1}(i) \tag{3.10}$$

$$\varphi_t(\mu, I) = \phi_\mu \left[\frac{\mu_t(i)}{\beta \mathbb{E}_t \mu_{t+1}(i)} \right] I_t(i) \tag{3.11}$$

Equation (3.8) describes the firm's maximisation value programme. Subject to the capital law of motion, the domestic firm navigates a two-tier real adjustment cost. First,

20 it faces an investment-to-capital ratio quadratic cost, derived from Turnovsky (2000). This first cost component captures the penalty incurred by the firm when it installs too many capital units. The second cost components incorporate the penalty of scaling back investment. In our model, domestic firms face real costs when they decide to scrape a plant for instance, and so need to keep a constant level of investment in order to avoid facing

25 these adjustment costs[1]. Domestic firms therefore need to tread a narrow path between

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[1]The proposed specification excludes capital from investment adjustment costs, and has been discussed in a similar format in Smets & Wouters (2007)

costs inherent to capital accumulation, as well as a cost of reducing their investment over time. The firm maximises equation (3.8) subject to the capital accumulation law of motion equation (3.9). Thus it means the firm seeks to maximise the discounted flows of its profits $D_t(i)$ net of investment, costs of capital instalment, which follows properties laid out in Turnovsky (2000). Our First-order conditions with regard to investment derive the dynamic properties to openness to trade at the firm level, which writes:

$$\mu_t(i) = \beta \mathbb{E}_t \mu_{t+1}(i) \left[\frac{q_t - 1}{\phi_k} - \frac{\phi_\mu}{\phi_k} \left(\frac{I_t(i)}{K_{t-1}(i)} - \delta_t(i) \right) \right] \tag{3.12}$$

Equation (3.12) is the nexus of our model. As a matter of course, the literature assumes that households in the home economy exhibit a constant domestic bias. Our model argues otherwise, stating that households face imperfect access to intermediate consumption goods instead. In an open economy setting, they import goods to supplement their consumption bundle. Our model establishes a direct link between imports and imperfect access consumption goods *via* real adjustment costs domestic firms face. On the one hand, capital-intensive goods are well-integrated in global trade, but on the other hand domestic firms face capital instalment costs. As a result, their production schedule is less efficient, and their productions more costly than those produced abroad. Furthermore, the combined effects of market power and adjustment costs generate a sub-optimal level of aggregate supply, which compels consumers to turn to imports as a result. Therefore trade integration dynamics for domestic can be explained by investment value and adjustment costs. Our model posits that firms decide on present openness to trade by forming expectations as to their future investment plans. Subsequently, equation (3.12) means that present openness to trade increases in expected benefits from future exposure to trade, as well as present marginal value of capital (The Tobin-Hayashi q-value) net of costs of adjustments captured by $\phi_{k,\mu}(.)$. Further first order conditions with regard to capital yield the following expression:

$$q_t = \beta \mathbb{E}_t q_{t+1} \left(1 - \delta_{t+1}(i) + \frac{\partial D_{t+1}(i)}{\partial K_t(i)} - \frac{\partial \phi_{k,\mu}(.)}{\partial K_t(i)} \right) \tag{3.13}$$

Equation (3.13) is the firm's equivalent of the Euler equation. It describes the dynamic evolution of the Tobin-Hayashi q-value with respect to capacity depreciation, capital returns to dividends, and future real adjustment costs. The present shadow price of investment is equal to its future discounted value, augmented with returns of capital use on dividends, net of depreciation and real adjustment costs. The q-value dynamics determine how much capital the firm is ready to invest, and thus how much it relies on capital to produce its good on the domestic market. We have established earlier that capital-intensive goods are more open to global trade, so the investment schedule described in equation (3.13) is going to determine the availability of domestic good i on

the market. Therefore, households' imperfect access to consumption goods stem from investment decisions and the effects of future depreciation and capital adjustment costs. If the firm anticipates large costs that dwarf expected profit returns from capital-intensive goods, it will install fewer capital units. As a result, the domestic firm's openness to trade
5 is low, and the product is more expensive than its imported competitor.

The investment schedule described above from equations (3.8) to (3.13) determines how much domestic firms invest in capital, in order to produce their goods. Domestic investment is a tradeoff between the marginal effect of additional capital on dividends, and associated costs, such as depreciation and real adjustment costs. Given that capital-
10 intensive goods are more integrated in the global trade, we establish a link between capital use and openness to trade.

To sum up, the key difference from the literature regarding domestic bias resides in linking openness to trade on the one hand, to capital-intensive goods on the other hand. Such a link is established *via* the introduction of real adjustment costs stemming
15 from capital instalment. Real costs are therefore a driving factor in generating imperfect access to consumption goods, which compels households to turn to imported goods to supplement their consumption. Trade in the small open emerging economy this paper seeks to model is thus defined by real costs of adjustment domestic firms face. Our model departs further from the literature by providing a micro-founded framework for
20 consumption and investment goods import. The follow sub-section presents and discusses trade dynamics in our setting.

3.3 Trade Balance

The open economy new Keynesian literature introduces the trade balance in terms of national accounting identity. Gali & Monacelli (2005) define that variable as the differ-
25 ence between domestic production and household expenditure.In some aspects the trade balance setup in this model is similar to the Gali-Monacelli model, in the sense that terms of trade or the real exchange rate are explicitly incorporated in the trade balance variable. In our model however, the constant domestic bias is replaced by imperfect access to consumption goods, which is contingent upon the domestic firms' investment schedule.
30 Nonetheless, our paper seeks to go beyond that definition, and offers a micro-founded formulation instead. We recall that our model does not differentiate between domestic and foreign goods[2], as it assumes that all available goods in the whole world can be produced domestically. Domestic firms however face real adjustment costs, which means

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[2]As mentioned at the beginning of this section, our model assumes that the small, open emerging economy can produce all goods available in global trade. As there are no differences between the same good produced at home or abroad, we focus on strategic interactions between domestic and foreign firms. Were such a differentiation to occur, the outcome would be a mixture between our model, and the Gali-Monacelli framework. Ultimately, it does not changes the basic conclusions of our paper.

that quantities do not meet consumer demand, and prices are higher than in an otherwise well-integrated economy.

The proposed definition for the firm-specific trade balance is intuitive: any shortfall in consumer demand that is not satisfied by firm-specific domestic production is going to be imported. There is also a difference between domestic and foreign prices from the shortfall that results from imperfect access to consumption goods. These frictions allows us to introduce in the model exchange rate dynamics, and more specifically, in the proposed definition for the trade balance variable. We denote $C_t^\star(i)$ and $P_t^\star(i)$ respectively intermediate demand and corresponding price expressed both under full access to consumption goods, *i.e.* for $\mu_t(i) = 1$. We compare its expression with that of intermediate demand, as reported in equation (3.5). We then re-write full access intermediate demand as a function of $C_t(i)$. The expression writes:

$$C_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{\frac{-\theta_t}{\theta_t - (\theta_t - 1)\mu_t(i)}} C_t^{\frac{1}{\theta_t - (\theta_t - 1)\mu_t(i)}} \tag{3.14}$$

$$C_t^\star(i) = \left(\frac{P_t^\star(i)}{P_t}\right)^{-\theta_t} C_t \tag{3.15}$$

Notice that the effective demand $C_t(i)$ is lower than its optimal counterpart $C_t^\star(i)$, and we write the fraction of intermediate demand that is satisfied with domestic production thus:

$$\frac{C_t(i)}{C_t^\star(i)} = \left(\frac{P_t(i)}{P_t^\star(i)}\right)^{-\theta_t} \left(\frac{P_t(i)}{P_t}\right)^{\frac{(\theta_t - 1)(1 - \mu_t(i))}{\theta_t - (\theta_t - 1)\mu_t(i)}} C_t^{\frac{(\theta_t - 1)(1 - \mu_t(i))}{\theta_t - (\theta_t - 1)\mu_t(i)}} \tag{3.16}$$

The expression encompassed in equation (3.16) can be interpreted as a substitution ratio between two consumption goods $C_t(i)$ and $C_t^\star(i)$, which depends not only on their respective prices $P_t^\star(i)$ and $P_t(i)$, but also on elasticity of substitution θ_t and openness to trade $\mu_t(i)$. One can easily verify that when the consumption good is fully produced at home for $\mu_t(i)$ then $P_t(i) = P_t^\star(i)$, and consumers are indifferent between $C_t(i)$ and $C_t^\star(i)$. Thus the firm-specific trade balance is sensitive to openness to trade, *i.e.* how much of the product is produced at home, its domestic pricing relative to its equivalent abroad, namely the real exchange rate, and finally households' elasticity of substitution and preference for diversity.

We have described the gap in intermediate demand generated by imperfect access. Consumption goods trade balance aggregates over all goods produced domestically and the quantities imported by households to make up for that gap. The expression writes in

log terms:

$$tb_t^c = \int_0^1 (\mu_t(i) - 1)(c_t(i) - c_t^\star(i))\mathrm{d}i \tag{3.17}$$

$$tb_t^c = \frac{(\theta_t - 1)(1 - \mu_t)^2}{\theta_t - (\theta_t - 1)\mu_t}c_t - \theta_t e_t \tag{3.18}$$

Our model writes the trade balance reported in equation (3.18) as a combination of openness to trade, elasticity of substitution and the real exchange rate. The trade balance in our model captures potential sources of exogenous shocks within the micro-founded framework of imperfect access to trade. In particular, the way trade is modelled predicts that highly autarkic economies will experience a substantial trade deficit when they open up a bit. This is due to the fact that the substitution effect dominates over all others, as households favour imported goods and domestic ones are comparatively too expensive. The same effect can be attributed to the exchange rate, as the domestic prices are higher than imported ones for the same good. Then as the economy increasingly integrate with global trade, firms produce larger quantities of cheaper domestic goods, and consumers are indifferent between domestic and foreign goods. High exposure to global trade means that integration dominates over the substitution effect and exchange rate mechanism.
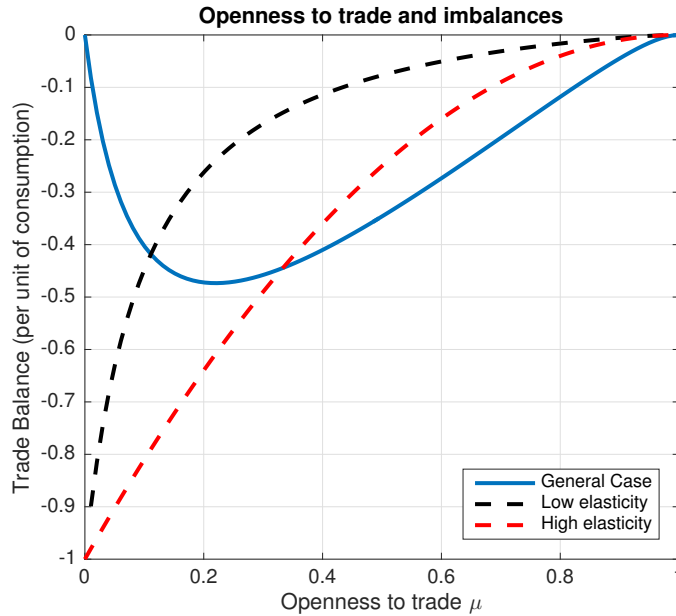

Figure 2: Trade balance deficit and openness to trade: consumption goods

Figure 2 plots trade deficit as a function of the degree of trade integration. Two special cases with extreme elasticity of substitution are compared against the more general setting captured by equation (3.16). The equation shows that when an autarkic economy opens

up, there is a steady trade deficit that accumulates as the economy integrates further with global trade. The deficit reaches an extremum beyond which households no longer prefer imported goods, as domestic production satisfies a growing share of their aggregate demand. When the economy is fully integrated in global trade, trade flows are balanced.

In a high elasticity regime, a small opening in autarkic economy generates a one-for-one increase in imports, as households shift their entire consumption to imported goods. The same reaction is observed in the low elasticity case, although the trade deficit contracts at a faster pace. This is due to the fact that domestic firms enjoy a large market power, which allows them to transition at a faster rate to capital-intensive goods and trade integration. The general case shows a U-shaped relationship between trade integration and balance deficit. An autarkic economy is defined by a low aggregate μ, so domestic goods are unable to satisfy aggregate demand, and their prices are relatively high. When the economy opens up, consumers substitute for imported goods, which generates a trade deficit. Its nadir signals to firms that the elasticity effect is overtaken by openness to trade, as domestic and imported goods are priced similarly. Domestic firms then invest in capital in order to integrate with global trade, hence reducing the trade deficit. This trade balance variable also captures the dynamic effects of exogenous shocks through consumption, openness to trade and the exchange rate. The model shows how the trade balance reacts to real shocks, such as a temporary change in productivity, or nominal shocks, such as markup or policy shocks.

The trade balance component described earlier deals only in consumption goods. Domestic firms themselves may also need to import capital units from abroad in order to invest and supplement their investment schedule. Our model defines in a similar manner the trade balance for investment goods, namely as a gap between the firm's desired level of investment, and that it can achieve given the constraints it faces. This is especially true given the fact that we have introduced real adjustment costs to capital instalments, as captured by equation (3.8). We thus define investment goods trade balance as the gap between realised and friction-free levels of investment due to openness to trade. The expression writes thus;

$$I_t(i) = K_{t-1}(i) \left[\delta_t(i) + \frac{\phi_k}{\phi_\mu} \left(q_t - 1 - \frac{\mu_t(i)}{\beta \mathbb{E}_t \mu_{t+1}(i)} \right) \right] \tag{3.19}$$

$$I_t^\star(i) = K_{t-1}(i) \left[\delta_t(i) + \frac{\phi_k}{\phi_\mu} \left(\frac{q_t - 1}{\phi_k} - 1 \right) \right] \tag{3.20}$$

Equation (3.19) rewrites equation (3.12) and expresses investment as a function of capital depreciation, its Tobin value net of costs associated to decreasing openness to trade. Equation (3.20) writes the special case where there are no adjustment costs associated with disinvestment. The trade balance denotes the gap in capital instalments between

the two expressions, and writes thus:

$$TB_t^I(i) = I_t(i) - I_t(i)^\star \tag{3.21}$$

$$TB_t^I(i) = \frac{\phi_k}{\phi_\mu} K_{t-1}(i) \left[\frac{\mu_t(i)}{\beta \mathbb{E}_t \mu_{t+1}(i)} \right] \tag{3.22}$$

$$tb_t^i(i) = k_{t-1}(i) + \phi_0 - \upsilon_t^\mu(i) \tag{3.23}$$

Where $\phi_0 = \ln\left(\frac{\phi_k}{\phi_\mu}\right)$ and $\upsilon_t^\mu(i) = \beta \mathbb{E}_t \mu_{t+1}(i) - \mu_t(i)$

Equation (3.22) describes the trade balance for investment goods at the firm level. It shows that when a firm increases its capital use, it imports additional capital units
5 from abroad in the form of foreign investment. In other terms, the future level of trade integration is higher than the present one, which means $\beta \mathbb{E}_t \mu_{t+1}(i) > \mu_t(i)$ and that creates a trade deficit in investment goods. The result laid out in equation (3.22) makes sense, and points to the larger point of how emerging economies can overcome chronic trade balance deficits. In such economies, various investment goods such as advanced
10 machinery are not produced locally, and therefore needs to be imported. When domestic firms start investing in in capital instalments in order to produce more capital-intensive goods, they need to import nonexistent capital on domestic markets. This creates a trade deficit, but only so far as the domestic firm integrate with global trade. In our model, an investment-driven trade deficit is sustainable, because of the following: first, it result in
15 domestic products being produced at quantities and prices converging with global levels. Households become indifferent between consuming domestic and imported goods thanks to capital intensity and trade integration. Consequently, the decline in aggregate demand for imported goods eases the pressure on aggregate trade deficit.

Such a case cannot be made for a consumption-driven trade deficit. It is true that
20 households benefit from imported goods, both in the quantities they bring to supplement their consumption bundle, and prices that are more competitive than domestic goods. However, if domestic firms do not invest, *i.e.* import investment goods as well in order to become more competitive and integrated in global trade, they are likely to be priced out of the market. The trade deficit is exacerbated as a result, since fewer domestic goods
25 means that consumers rely even more on imports.

Dynamics affecting consumption and investment imports have repercussions on the aggregate trade balance, which are proportional to the respective contributions of investment and consumer goods in total imports. The expression writes thus:

$$tb_t = \frac{\bar{tb}^c}{\bar{tb}} \tilde{tb}^c{}_t + \frac{\bar{tb}^i}{\bar{tb}} \tilde{tb}^i{}_t \tag{3.24}$$

The proposed definition of the trade balance affords us the opportunity to examine

the impact of exogenous shocks on trade flows in a small open emerging economy. We have shown that the trade deficit for consumption goods evolves following the changes between substitution and openness to trade effects. We have also shown that investment goods trade deficits are generated when domestic firms have an incentive to increase their capital instalments. As a result, the model describes a more comprehensive definition of the trade balance, based on solid micro-foundations. The foray into this issue bear a direct link to this paper's state objective of formulating a micro-founded Phillips curve. These trade dynamics are the result of existing real and nominal rigidities, which are necessary to formulate micro-foundations for openness to trade. This model component features prominently in our alternative specification to the new Keynesian Phillips curve.

3.4 Price sluggishness & the new Keynesian Phillips Curve

In a departure from the Walrasian general equilibrium model, the new Keynesian synthesis makes use of imperfect competition and price sluggishness for two reasons: first, it gives firms price-setting powers, which sets output below its competitive level. A sub-optimal level of output gives room for macroeconomic policy instruments, such as monetary policy. Second, price sluggishness generates inflation and other nominal variables, as price adjustments are not instantaneous. These micro-foundations are key to building a new Keynesian Phillips curve. Following Woodford (2005), the standard specification to the new Phillips curve writes:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \xi \tilde{s}_t \tag{3.25}$$

Where π denotes the inflation rate, and $\tilde{s}$ the deviation of average logged marginal cost from its-steady-state value. It is usually assumed that $\tilde{s}$ is proportional to the output gap, *i.e.* the log difference between its actual level, and prevailing output in a flexible price equilibrium. Notice also that equation (3.29) is purely forward-looking, and thus does not include lagged inflation. Previous iterations of the new Phillips curve did include past inflation, as is the case in Fuhrer & Moore (1995). Their specification assumes that prices are determined by contract wages *à la* Taylor (1980). In the staggered wage contracts model, current prices are an average of staggered wage contracts. Their Phillips curve writes thus:

$$\pi_t = \frac{\pi_{t-1} + \mathbb{E}_t \pi_{t-1}}{2} + \frac{\gamma}{2} \hat{y}_t \tag{3.26}$$

Where $\hat{y}_t$ denotes a a moving average of current and past output deviation of its long-run trend, the model's own proxy for the output gap. Ireland (2004) proposes a more comprehensive new Keynesian framework that assumes economic agents allocate weights

to future and past inflation, where the proposed new Phillips curve writes:

$$\pi_t = \beta \left[\alpha_\pi \pi_{t-1} + (1 - \alpha_\pi) \mathbb{E}_t \pi_{t+1} \right] + \psi \tilde{o}_t - \theta_t \tag{3.27}$$

Ireland then estimates the structural parameters of his new Keynesian model in U.S. data, and finds the attached coefficient to past inflation α_π to be statistically not significant. It is also difficult to argue from a micro-foundation standpoint that economic agents base their inflation expectations on past values when the proposed model is based on rational expectations and forward-looking optimisation. It is therefore more rigorous to assume that agents do not take into account lagged values in their inflation/output gap tradeoff. This choice can be further justified by the fact that inflation persistence can be replicated thanks to real rigidities, thus providing a more consistent theoretical background. As we check our model's fitness to replicate the data, we find that it is able to reproduce inflation persistence in our country sample, without resorting to lagged inflation *à la* Fuhrer-Moore.

3.5 A digression on Calvo *vs.* Rotemberg

The micro-founded new Keynesian synthesis appears to have formed a consensus around the staggered Calvo price-setting as a means to capture price stickiness. It is favoured in particular for its tractability, and the fact that it fits well with post-war U.S. data. As reported in Woodford (2003), the Calvo measure in Sbordone (2002) is predicated on the assumption that labour unit costs are a cogent measure of the marginal cost, and a good predictor of price changes. Nevertheless, the Calvo price-setting is favoured despite its underlying assumption that firms face a fixed probability of price change.

It has been argued above that there are limitations to the literature's choice of wage deviations as proxy for the marginal cost, and thus the output gap. The use of Calvo staggered price-setting may not introduce sufficient price stickiness to formulate an adequate specification of the NKPC in emerging economies. Subsequently, we choose in this paper to introduce price sluggishness by means of adjustment costs mechanisms devised by Rotemberg (1982), as presented in Bénassy (2001). We contend that the Rotemberg adjustment cost component is more apropos to the importance of real rigidities as discussed in Ball & Romer (1990). The Rotemberg mechanism also provides a more coherent view of how firms in emerging economies face price sluggishness.

Furthermore, a cornerstone of our model is the assumption that households have imperfect access to consumption goods. It is the case because firms face real adjustment costs in their capital instalment schedule. These adjustment costs can be conflated with the Rotemberg mechanism, since it implies that firms also face real cost to adjust their prices.

Klenow & Malin (2010) use microeconomic studies to show that the degree of price stickiness varies within their selected sample, where European and U.S. economies tend to have more stable prices than those labelled high-inflation, emerging economies. Vegh (2013) aggregates studies on mean price duration between developed and emerging economies, and shows that the former is about twice as long at 5.5 months, *versus* 2.6 months in the latter. The discrepancy is high enough to cast doubt as to the relevance of the Calvo price-setting mechanism in emerging economies. We therefore posit that market structures in emerging economies are such that firms are not faced with a random adjustment of prices, but rather deal with a cost to updating their prices, such as menu cost. Third, while Lombardo & Vestin (2008) agree that under Calvo-pricing expected consumption is lower compared to Rotemberg-pricing, the consumption gap holds only as far as the steady-state is efficient. Such an assumption does not necessarily hold for an emerging economy, and an inefficient steady-state actually fits better with the Rotemberg adjustment cost, as it yields a permanently sub-optimal production, absent exogenous shocks. We have stressed before the importance of real rigidities and their impact on the steady-state. The fact that real wedges are more significant in emerging economies means that their computed steady-states are inefficient. Therefore, welfare computations based on Calvo partial indexation are bound to be biased - whereas results derived from the Rotemberg mechanism remain impervious to the change.

In addition to the methodological issues raised above, we also point to empirical results that weaken the relevance of Calvo price-setting in emerging economies, and bolster the case for Rotemberg price-setting. Lombardo & Vestin (2008) show that under Calvo, consumers will substitute their consumption in a manner that does not reflect each firm's relative cost of production, since prices adjust randomly. By contrast, the Rotemberg mechanism assumes that firms do face price adjustment costs, which reflects on their respective production schedule, therefore reducing the amount of available goods for consumption. We argue that the Rotemberg mechanism thus is more apropos for three reasons. First, under Rotemberg, exogenous shocks drain available resources, and agents increase their expenditure of scarce resources, which reduces social welfare. Second, there are significant differences in mean duration for CPI price changes between emerging and developed economies.

The brief discussion of Calvo *v.* Rotemberg sheds some light as to the issues facing a modified new Keynesian model adapted to emerging economies. We posit that the Rotemberg adjustment cost component fits better with the overall outlook of our model, we characterise firms' profit-making schedule with respect to real adjustment costs.

3.6   The open economy New Keynesian Phillips curve

We follow Bénassy (2001) in defining the firm's price adjustment cost constraint, and posit that it faces a lifetime penalty, which she seeks to minimise. The programme writes thus:

$$\min_{p_t(i)} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\phi_1}{2} \left(p_t(i) - \bar{p}_t(i) \right)^2 + \frac{\phi_2}{2} \left(p_t(i) - p_{t-1}(i) \right)^2 \right] \tag{3.28}$$

5   The individual firm incurs costs over time for two components. The first is the penalty for deviating from the socially desirable price level, that is, the flexible pricing setup and optimal capacity utilisation per equation (3.1). The second component describes the cost incurred by the firm when it seeks to change its price from one period to the other. Minimisation of equation (3.28) with respect to $p_t(i)$ yields:

$$\pi_t(i) = \beta \mathbb{E}_t \pi_{t+1}(i) - \frac{\phi_1}{\phi_2} \left[\mu_t(i) + \theta_t - \tilde{o}(\upsilon_t(i)) \right] \tag{3.29}$$

10   Where $\pi_t(i)$ and $o(\upsilon_t(i))$ refer respectively to the firm-specific inflation rate and capacity utilisation. Equation (3.29) describes a firm-specific, forward-looking Phillips Curve augmented with an openness to trade component, and a cost-push shock component captured by θ_t. In order to consolidate these curves into an aggregate Phillips Curve, we define the inflation rate as a weighted integral over firm-specific inflation rates with
15   their respective openness to trade. The new Keynesian Phillips Curve augmented with openness to trade in our model writes thus:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} - \frac{\phi_1}{\phi_2} \left[\theta_t + \mu_t + \upsilon_t^\mu - \tilde{o}(\upsilon_t) \right] \tag{3.30}$$

The proposed Phillips curve is forward-looking, where inflation depends not only on cost-push shocks and the output gap, but also on openness to trade and an exogenous shock denoted υ_t^μ. This component seeks to capture the effects generated by an additional
20   mass of consumption goods that become available on the domestic market[3].

This alternative Phillips curve is different from the standard specification and that offered in the Gali-Monacelli on several aspects. First, the domestic bias is no longer constant and is endogenous. Openness to trade shows clearly to exercise downward pressure on inflation. Second, thanks to real capital costs of adjustment, the proposed Phillips
25   curve introduces real rigidities and can adequately capture the counter-intuitive impact of an inflationary increase in interest rates, as discussed in Christiano & al (2011). In our model, firms need to invest in capital units in order to be competitive against imported goods. An increase in interest rates signals rising marginal costs, which prompts firms either to reduce their investment and incur additional costs, or switch to labour-intensive

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[3]This exogenous shock is in keeping with the critique levied in Chari, Kehoe & McGrattan (2009)

production, which increases costs as well. In either case, domestic firms are likely to pass on these cost increases to their prices. On the other hand, monetary policy can reduce inflation by tamping down domestic demand. As observed in Ball & Romer (1990) real rigidities can improve on the model's ability to replicate nominal stickiness. In our case, adjustment costs to capital instalment as well as real price adjustment costs provide enough distortion in the economy to general nominal variables within the proposed framework of an open emerging economy.

In the open economy setting, these dynamics make sense: at the firm level, production of less capital-intensive goods means a more autarkic domestic production, and more expensive products. At the aggregate level, an increase in nominal interest rates compels individual firms to reduce the size of their respective capital instalments. Since they cannot instantaneously adjust their capital stock due to costs of adjustment, they pass on the expenditure to their marginal cost and prices.

Given the production function used by individual firms in equation (3.1), the minimisation of production costs writes:

$$\frac{R_t K_{t-1}(i)}{W_t N_t(i)} = \frac{\alpha}{1-\alpha} \upsilon_t(i) \tag{3.31}$$

What differentiates firms in terms of cost structure is their respective capital utilisation, as well as the firm-specific output gap. The flexible pricing formula in equation (3.7) writes thus:

$$P_t(i) = \mu_t(i) \frac{\theta_t}{\theta_t - 1} \frac{W_t^{1-\alpha} R_t^{\alpha}}{(1-\alpha) Z_t} \left(\frac{1-\alpha}{\alpha \upsilon_t(i)}\right)^{\alpha} \tag{3.32}$$

Equation (3.32) shows up on the new Keynesian Phillips Curve with openness to trade, cost-push and output gap, expressed in terms of capital utilisation.

Equation (3.30) shows an alternative specification to the New Keynesian Phillips Curve. We have introduced an explicit component that seeks to capture the effects of openness to trade in determining inflation. As shown in equation (3.13), the domestic firm faces a tradeoff when it comes to its investment schedule: on the one hand, additional units of capital can increase its competitiveness and expose its product to global trade. On the other hand, the firm faces real adjustment costs when it seeks to ramp up its investment. For households in the small economy, this tradeoff results in imperfect access to consumption good. When a small mass of domestic firms decide to invest more, this generates an exogenous shock, which results in increased domestic production and higher competition. The resulting decline in domestic firms' markup drives prices down, and generates a disinflationary effect.

Domestic firms' investment schedule sensitivity to real adjustment costs can also generate unintended policy consequences. Following a similar argument in Christiano & al.

(2011) an increase in nominal interest rates, designed to reduce inflation, may have the opposite effect. Firms face costs of adjustment in their investment schedule. As a result of the Hayashi mechanism, firms pass on capital costs of adjustment to their marginal cost, and thus generate inflation.

⁵   This section has been dedicated to formulate an alternative new Keynesian Phillips curve. It incorporates openness to trade as well as real rigidities that can adequately replicate the effects of increased integration in global trade on the one hand, and inefficient capital utilisation. We also provide a micro-founded framework for the trade balance on consumption and investment goods. The second component to the new Keynesian syn-
¹⁰ thesis is the IS-equation, which combines production capacity with real expected interest rates. In the section below we proceed in a similar fashion in formulating a micro-founded IS equation with explicit additional components of global trade.

3.7   Consumers and IS equation.

We have extensively discussed in the section above the alterations made to the Phillips
¹⁵ curve in a small, open emerging economy. We now move to the other pillar of the new Keynesian synthesis, namely the micro-founded IS equation. We follow Ireland (2001) and McCallum & Nelson (1999) in their attempt to conciliate the standard Keynesian model with a general equilibrium setting. Given the fact that the IS equation represents aggregate demand's sensitivity to real interest rates, it makes sense to use the representa-
²⁰ tive household's utility function, which combines consumption, real balance, and labour, respectively. The lifetime utility function writes:

$$U(.) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[A_t \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right] \tag{3.33}$$

A_t is a demand shock, defined as follows:

$$a_t = \ln A_t \Rightarrow a_t = \rho_a a_{t-1} + \epsilon_t^a \tag{3.34}$$

Households seek to maximise their utility function in equation (3.33) subject to their budget resources:

$$P_t C_t + Q_t B_t \leq B_{t-1} + W_t N_t \tag{3.35}$$

²⁵   Consumption is valued at aggregate price P_t which combines domestic and imported goods. First order conditions yield the log-linearized Euler equation, which writes:

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\sigma} \left(i_t - \mathbb{E}_t \pi_{t+1}^{\star} + \ln \beta \right) + \frac{1-\rho_A}{\sigma} a_t \tag{3.36}$$

Equation (3.36) rewrites the standard Euler equation in log-linear form. It is the basis

for the new Keynesian IS equation, and will show the standard components of output gap, domestic inflation and the real exchange rate, following Gali & Monacelli (2005).

One key outcome from the new Keynesian synthesis is that market imperfections result in a sub-optimal level of output, which in turns introduces macroeconomic policy as a mean to correct it. These imperfections are accounted for by the following two mechanisms: first, the fact that intermediate firms have price-setting powers, implies that their respective production is below a level they would otherwise supply in a competitive setting. Second, there are disparities in production between firms who charge too high a price, or produce too few products. The output gap can therefore be defined as the production shortfall that results from such market imperfections, *i.e.* the gap between actual output and the level that would prevail under flexible prices and a competitive regime.

This paper builds a definition of the natural level of output on those offered by Ireland (2001) and Christiano & *al.* (2011). Their shared definition of the natural level of output assumes the existence of a social planner who acts as a natural monopoly seeking to maximise aggregate welfare. The maximisation programme implicit to the social planner is similar to the competitive equilibrium derived in a Real Business Cycle setting. In addition, Christiano & *al.* (2011) further show that solving the representative consumer's optimisation programme is akin to solving for a Ramsey rule. We favour solving for the social planner's programme, as it provides a more tractable expression to the natural level of output.

The literature however does not seem to define an exclusive or unique criterion, nor does it appear to be an issue that needs clarification. In his assessment of cycle-smoothing policies and expected welfare gains, Lucas (2003) notes that there is no single way of going about comparing consumer welfare, the only constraint being that welfare outcomes should be comparable in terms of consumption units. The same can be said as to the definition of the natural level of output. We argue that a definition predicated on a pure Walrasian setting sets the natural level of output too high, and thus overstates the output gap for emerging economies. It provides a biased predictions as to what macroeconomic policy can achieve accordingly. We use the argument laid out in Ball & Romer (1990) regarding real rigidities in order to to refine our contention further. Emerging economies may not exhibit efficient steady-state, and by the same reasoning their natural level of output may not be frictionless. This point is critical to our welfare analysis, as to monetary policy regimes in an open emerging economy.

We combine Ireland (2001) and Christiano & *al.* (2011) to formulate the social planner's optimisation programme, which consists of maximising discounted expected consumer utility flows subject to resource constraint. In this setting, intermediate firms are no longer price-setters, and the social planner acts as a natural monopolist whose surplus

coincides with aggregate welfare. In essence, the natural level of output we are computing is analogous to the prevailing level in a Real Business Cycle setting, *i.e.* one where there are no market imperfections or price stickiness, but not necessarily frictionless. The optimisation programme writes:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[A_t \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right] \tag{3.37}$$

⁵ subject to:

$$Y_t = Z_t N_t^{1-\alpha} K_{t-1}^{\alpha} \tag{3.38}$$

$$I_t = K_t - (1-\delta)K_{t-1} \tag{3.39}$$

$$Y_t = C_t + I_t \tag{3.40}$$

In order to make computations more tractable, we follow Christiano & *al.* (2011) in rewriting household expenditure and investment such that they represent fixed proportions of output. As far as the resource constraint goes, it means that both variables have to be expressed relative to productivity, and the new optimisation programme writes:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[A_t \frac{\left(Z_t^{1/(1-\alpha)} \tilde{C}_t \right)^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right] \tag{3.41}$$

¹⁰ subject to:

$$\tilde{C}_t + \tilde{I}_t = N_t^{1-\alpha} K_{t-1}^{\alpha} \tag{3.42}$$

Where:

$$\tilde{C}_t = \frac{C_t}{Z_t^{1/(1-\alpha)}} \tag{3.43}$$

$$\tilde{I}_t = \frac{I_t}{Z_t^{1/(1-\alpha)}} \tag{3.44}$$

Solving further for the natural level of consumption expenditure yields the logged natural level of output (expressed in consumption terms):

$$\tilde{c}_t = \frac{a_t}{\sigma} + \frac{\sigma - 1}{\sigma(1-\alpha)} z_t - \frac{\phi + \alpha}{\sigma} n_t - \frac{\alpha}{\sigma} \tag{3.45}$$

Notice that the natural level of consumption is function only of real shocks, namely ¹⁵ demand and productivity. We can also predict that it is more sensitive to the latter, since $\sigma > 1$ and $\alpha < 1$, which squares with the underlying assumption that the natural level of output. Furthermore, we observe that openness to trade does not feature in this expression, because of the explicit assumption attached to the optimisation programme,

about market structure and the absence of any imperfections or frictions.

We plug the expression for the natural level of consumption in the Euler equation (3.36) in order to write the forward-looking IS equation of the new Keynesian synthesis. The result writes:

$$\tilde{o}_t = \mathbb{E}_t\tilde{o}_{t+1} + \varphi_0 + \varphi_z z_t + \varphi_a a_t - \frac{1}{\sigma}\left(r_t - \mathbb{E}_t\pi_{t+1}^{\star} + \ln\beta\right) \tag{3.46}$$

Where $\tilde{o}_t$ denotes the output gap, and:

$$\varphi_0 = \frac{\phi + \alpha}{\phi\sigma} \tag{3.47}$$

$$\varphi_z = \frac{(1 - \rho_z)(\sigma - 1)}{\sigma(1 - \alpha)} \tag{3.48}$$

$$\varphi_a = \frac{2(1 - \rho_a)}{\sigma} \tag{3.49}$$

Observe that $\varphi_z > \varphi_a > 0$ which means that the IS equation is more sensitive to productivity shocks. The Euler equation was computed on the basis of the overall consumption bundle, so its inflation reflects prices from imported goods as well. We rewrite intermediate demand in equation (3.14) in order to express the inflation differential as a function of openness to trade and the exchange rate. The expression writes:

$$\pi_t = \pi_t^{\star} + (1 - \mu_t)\left(\frac{\theta_t - 1}{\theta_t}\right)c_t - \psi_t e_{t-1} \tag{3.50}$$

Equation (3.50) illustrates the dynamics described in the section earlier. Domestic inflation π_t is decreasing in aggregate openness to trade, captured by μ_t. The relationship between the two variables is indirect, as openness to trade affects aggregate consumption thanks to increased variety in intermediate goods, as well as elasticity of substitution. A fully integrated economy in global trade synchronises its inflation worldwide, and we get $\pi_t = \pi_t^{\star}$. Imperfect access to foreign goods has an impact on domestic prices as well, which generates exchange rate dynamics. Equation (3.50) shows that the effect of the latter is lagged, which is due to costs of adjustment discussed earlier in equation (3.28).

The IS equation (3.46) augmented with equation (3.50) does equate the output gap with the inflation differential that arises from imperfect access to goods. However, it understates the impact of the former on the natural level of output. We offer an alternative expression, one that incorporates real rigidities in the form of capital adjustment costs similar to those specified in equation (3.8). This definition of the natural level of output can still be considered RBC-based, though augmented with real rigidities that persist at the steady-state. In order to compute this alternative measure of natural output, we need to specify capital stock and investment schedule with respect to those adjustment costs specified in equation (3.8). The level of investment is rewritten with respect to technology

so as to represent a fixed proportion of output. Investment under real adjustment cost writes:

$$\hat{I}_t = K_{t-1}\left[\delta + \frac{q_t - 1}{\phi_K} - \frac{\phi_\mu}{\phi_K}\frac{\mu_t}{\beta\mathbb{E}_t\mu_{t+1}}\right] \tag{3.51}$$

Which yields a lower level of investment due to adjustment costs ϕ_K and ϕ_μ, thus slowing down capital accumulation. Consequently, output is lower and less capital-intensive. In addition to capital adjustment costs *à la* Turnovsky (2000), we have also defined adjustment costs to slowing down, or scaling back openness to trade, captured by the expression multiplied by ϕ_μ. The social planner also incurs penalities when she decides to reduce investment, and thus openness to trade, over time. Solving for the social planner's maximisation programme with respect to equation (3.51) yields the following expression for the natural level of consumption (relative to productivity)

$$\tilde{c}_t^k = \frac{a_t}{\sigma} + \frac{\sigma - 1}{\sigma(1-\alpha)}z_t - \frac{\phi + \alpha}{\sigma}n_t - \frac{\alpha}{\sigma} + (1-\alpha)\tilde{k}_{t-1} + \psi\left(\delta + \frac{q_t - 1}{\phi_K} - \frac{\phi_\mu}{\phi_K}\frac{\mu_t}{\beta\mathbb{E}_t\mu_{t+1}}\right) \tag{3.52}$$

Notice that natural output as reported in equation (3.52) incorporates capital and investment value, respectively denoted $\tilde{k}_{t-1}$ and q_t. It increases in both arguments, but is ultimately lower compared to the frictionless level of natural output reported in equation (3.45) because of the larger cost to disinvestment linked to openness to trade. The alternative IS equation expresses the output gap in addition to the terms reported in equation (3.46), capital growth and marginal value, as well as the exogenous shock of openness to trade. The expression writes:

$$\tilde{o}_t = \mathbb{E}_t\tilde{o}_{t+1} + \varphi_0 + \varphi_z z_t + \varphi_a a_t - \frac{1}{\sigma}\left(r_t - \mathbb{E}_t\pi_{t+1}^\star + \ln\beta\right) + \varphi_q \mathbb{E}_t q_{t+1} + (1-\alpha)\Delta\tilde{k}_t - \varphi_\mu \upsilon_t^\mu \tag{3.53}$$

This section has been devoted to formulating an alternative new Keynesian framework, where trade dynamics are explicitly incorporated in the Phillips curve and IS equations. We have formulated a micro-founded framework built on real rigidities, in this case imperfect access to consumption goods due to capital instalment adjustment costs. Following the Ball-Romer argument, we show that real rigidities prove to go a long way in replicating price stickiness. The same micro-founded framework also allows us to formulate an alternative specification to the trade balance, as well as the dynamics between domestic and worldwide inflation on the one hand, and the real exchange rate on the other hand. We now seek to apply the model to a set of emerging economies, describe its predicted results, and evaluate their relevance with respect to the literature and a selected sample of stylised facts.

3.8   Calibration and model simulation

The alterations introduced in the new Keynesian synthesis framework are guided by a key principle: real rigidities stemming from capital adjustment costs result in imperfect access to consumer goods. This in turns features explicitly in our modified New Keynesian Phillips curve, where openness to trade as a variable captures the ambiguous effects imported goods have on inflation and the output gap. We seek to apply this model to a selected sample of emerging economies, in order to check on its overall coherence, and compare its predict results with stylised facts reported in the literature.

Kydland & Prescott (1991) lay out a fairly comprehensive setting for calibration in order to make it as rigorous as possible. They insist that picking credible values for structural or deep parameters implies a certain degree of discipline that relies on households and individual surveys for instance, as well as long-run averages and growth rates of relevant macroeconomic aggregates. calibration also assumes that given the broad definition Dynamic Stochastic General Equilibrium (DSGE) models bestow on some parameters, their values should essentially be the same across the literature, if not countries. Ultimately, their argument is based on the view that the model should be parsimoniously parameterised, and that its micro-foundations, specifically inter-temporal optimisation, are more important.

The literature on emerging economies tends to embrace this view: Garcia-Cicco, Pancrazi & Uribe (2010) in their study of Real Business Cycles in emerging economies calibrate their model to match empirical moments for Argentina, and rely on credible values commonly found in the literature.

There are several caveats to be aware of, though: data from emerging economies places limitations as to how many parameters can be calibrated. Similarly, the use of similar values common to developed economies can be indiscriminately applied to emerging ones. One particular instance is the discount factor used by households for their utility flows. DSGE literature focused on developed countries uses short-run interest rate to calibration a value that is usually close to .99 (in quarterly data) whereas emerging economies experience a significantly higher average interest rate, and thus exhibit lower values for the discount factor. Such a case has been discussed in Garcia-Cicco & al. (2010), and the conclusion was to choose the calibrated, rather than estimated value instead.

In order to address these issues, we take an intermediate position: for those parameters where data is readily available to compute long-run averages and correlations, we proceed according to Kydland & Prescott (1991). For those parameters that feature in inter-temporal equations or optimality conditions, we rely on estimation to extract their values. In particular, we use GMM-based estimation to provide numerical values for those parameters that cannot be calibrated. As far as calibration applied to emerging economies goes, we are faced with the twin constraint of data availability, a fact thor-

oughly discussed in Agénor, McDermott & Prasad (2000) and updated in Schmitt-Grohé & Uribe (2017). The second constraint is that of the new Keynesian synthesis we are using to build our model. The barest form of new Keynesian models, as introduced in Clarida, Gali & Gertler (1999), and formalised as a fully-fledged DSGE model in Ireland (2001) are parameter-rich, much more so than earlier iterations of the RBC framework Kydland & Prescott (1991) refer to in their paper.

We focus on a small set of emerging economies from the Middle-East & North Africa (MENA) economies to calibrate and estimate structural parameters in our model. Garcia-Cicco, Pancrazi & Uribe (2010) have simulated the business cycles of Latin American economies, and we would like to investigate the model's performance with respect to another group of emerging economies. Table 3 below summarises those according to their interpretation, support for credible values, and method of computation.

Table 3: Calibrated and estimated values for structural parameters.

	Parameter	Range	Value	Method	Source
β	Discount factor	< 1	0.989	Calib.	Data (WDI)
σ	CRRA factor	$\in [1, \infty[$	2.67	GMM	Euler
ϕ	Labour elasticity	$\in [1, \infty[$	1.24	Calib.	Matches time allocated to work
α	Capital share of production	$)0.1($	0.321	Calib.	TFP Estimation
δ	Capital depreciation	$)0.1($	0.021	GMM	Euler
ω_1	Variable depreciation	$\mathbb{R}^{+*}$	0.097	Idem	Idem
ω_2	Variable depreciation	$\in [1, \infty[$	1,26	Idem	Idem
ϕ_1	Price adjustment cost	$\mathbb{R}^{+*}$	1.23	Idem	Phillips Curve
$\phi2$	Price adjustment cost	Idem	1.26	Idem	Phillips Curve
ϕ_K	Capital adjustment cost	Idem	6.5	Idem	Tobin's Q
ϕ_μ	Investment adjustment cost	Idem	6.34	Idem	Idem
ρ_R	Interest-rate smoothing	$)-1.1($	0.786	GMM	Taylor Rule
ρ_π	Policy rate weighting - inflation	Idem	0.567	Idem	Idem
ρ_G	Policy rate weighting - output gap	Idem	0.01	Idem	Idem
ρ_θ	Persistence - Markup	Idem	0.67	Calib.	Ireland (2004)
ρ_a	Persistence - Demand	Idem	0.733	Idem	Idem
ρ_z	Persistence - Productivity	Idem	0.877	GMM	TFP Estimation
ρ_μ	Persistence - Openness to trade	Idem	0.67	GMM	Import & Export Data (WDI)

4 Monetary policy regimes and welfare analysis

As mentioned earlier, the model describes a small, open emerging economy where individual firms are price-setters over their intermediate goods, and face real price adjustment costs. The combination of real and nominal rigidities depresses output below its competitive level, thus households have an imperfect access to all available goods worldwide. As a result, they resort to import some of these to supplement their aggregate consumption bundle. The combined effects of monopolistic competition and imperfect access to intermediate goods generate output below its optimal level, and given sluggish price adjustment, monetary policy has an impact on real variables. Following Rotemberg & Woodford (1999) and Gali & Monacelli (2005) we review an array of policy instruments available to monetary authorities, and assess their respective impact on welfare.

In contrast with the consensus in the literature, we argue that welfare losses should be computed with respect to the competitive or flexible prices regime, rather than the steady-state. Based on the nature of macroeconomic fluctuations driven by real factors, over which agents and policymakers have no power. Indeed, it is a given that macroeconomic fluctuations in a Real Business Cycle framework are agents' optimal responses to exogenous shocks. Therefore, macroeconomic policies are likely to yield little to no improvement in agents' welfare. As a result, welfare losses computed with respect to the steady-state are likely to be over-estimated, and thus yield inaccurate policy recommendations. Instead, we present in this section an alternative welfare analysis based on deviation with respect to the competitive level, proxied in this case by the RBC framework.

4.1 Welfare criterion

The new Keynesian synthesis framework introduces monopolistic competition and price stickiness in order to lay out micro-foundations for market structure imperfections. The fact that intermediate firms are price-setters, and face nominal rigidities in setting their prices, means that aggregate output is below its competitive, flexible-price level. In particular, Christiano, Trabandt & Walentin (2011) show that output loss is due to price dispersion, and firms produce less as a result of imperfect substitution between their respective goods. In addition, price dispersion drives some firms to over-produce, while others do not, depending on how price dispersion affects their respective production and profit-making schedules. Such an argument has been initially laid out in Yun (1996). In Yun's specification, the relationship between the two levels of output can be written as follows:

$$Y_t = \left(\frac{P_t}{P_t^\star} \right)^{\theta_t} Y_t^\star \tag{4.1}$$

Where $Y, Y^\star$ refer respectively to output and its competitive level. $\left(\dfrac{P_t}{P_t^\star}\right)^{\theta_t}$ refers to price dispersion, *i.e.* which increases in imperfect substitution between intermediate goods.

In our setting price dispersion is not the sole source of output inefficiency. The model incorporates real rigidities in the form of capital and investment adjustment costs, imperfect access to consumption goods, as well as strategic interactions between domestic and foreign firms. All these imperfections are bound to bring output further below its competitive level. We argue that these factors can better explain output shortfall in a small, open emerging economy. In order to show that, we use the Yun (1996) argument and write output as a function of its competitive level on the one hand, and market imperfections, strategic interactions and real rigidities on the other hand.

In the competitive setting, intermediate firms lose their price-setting market power, and are thus each given the same weight, so the competitive level of output denoted $C_t^\star$ writes:

$$C_t^\star = \int_0^1 C_t(i)\mathrm{d}i \tag{4.2}$$

We combine this expression with equation (3.5) to write output as a function of its competitive setting and market imperfections, thus:

$$C_t^\star = C_t \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\theta_t} \left(\frac{P_t(i)}{P_t}\right)^{\dfrac{\theta_t(\theta_t - 1)(1 - \mu_t(i))}{\theta_t - (\theta_t - 1)\mu_t(i)}} C_t^{\dfrac{(\theta_t - 1)(1 - \mu_t(i))}{\theta_t - (\theta_t - 1)\mu_t(i)}} \mathrm{d}i \tag{4.3}$$

The expression in equation (4.3) is written so that each component is isolated, and to better account of those components that bring down output away from its competitive level. The first component is similar to to the Yun (1996) formula, which is to say the price dispersion effect. The other two components break down the effects of imperfect access to consumption goods, as well as strategic interaction between domestic and foreign goods. The additional components reflect strategic interactions between domestic and foreign goods and their effects on pricing and the aggregate level of consumption, respectively. One can see that when all domestic firms are fully opened to trade, *i.e.* $\mu(i) = 1$ then output loss is attributable to price dispersion alone.

Furthermore, equation (4.3) reports the ambiguous effects of openness to trade as reported in Watson (2016). On the one hand, even if price dispersion is suppressed, output remains below its competitive level due to imperfect access to consumption goods. This is due to the fact that domestic intermediate firms no longer base their pricing decision schedule on changes in their respective marginal costs. Instead, strategic interactions gen-

erate enough rigidities to lower output, regardless of price dispersion. On the other hand, increased openness to trade means that more consumption goods are available, hence production increases to meet demand, and for $\mu(i) = 1$ only price dispersion prevents output to reach its competitive level. In addition, households also have access to a lower
5 level of consumption goods due to imperfect access, as generated by real adjustment costs facing domestic firms, even if price dispersion is entirely eliminated. We argue below that deviations from the competitive regime are a more apropos measure of welfare losses than the steady-state, as argued in the literature.

The welfare criterion used in this section is based on equation (4.3). In contrast with
10 Woodford & Rotemberg (1999), welfare losses in our model are not computed in terms of departure from an efficient consumption steady-state. Instead, the model makes an analogy of Lucas' (2003) approximation of welfare gains from smoothing consumption. We posit that there are welfare losses to households in terms of utility consumption between the competitive regime and available goods for consumption. We introduce the
15 following alterations to the Lucas framework: first, welfare losses are computed with respect to the desirable competitive regime, which is proxied in this instance by the RBC framework. Second, the desirable consumption regime in this model does not eliminate fluctuations. On the contrary, we posit that the RBC-based consumption regime reflects agents' optimal response to stationary shocks, and as such a Pareto-dominant outcome
20 they can achieve. Third, welfare losses are not constant, and are subject to fluctuations in those variables reported in equation (4.3).

The selected criterion fits within the overall narrative of this paper: market imperfections and real rigidities bring output below its competitive level. Welfare losses can therefore be proxied by the amount of consumption goods lost to households, or in our
25 case, in terms of marginal utility percentage losses. In particular, the welfare criterion denoted $\mathbb{W}'_t$ writes:

$$\mathbb{W}_t = \ln u(C_t) - \ln u(C_t^\star) \tag{4.4}$$

$$\mathbb{W}_t = \sigma \left[\frac{\theta_t}{\theta_t - (\theta_t - 1)\mu_t} \pi_t + \frac{(\theta_t - 1)(1 - \mu_t)}{\theta_t - (\theta_t - 1)\mu_t} c_t \right] \tag{4.5}$$

$$\mathbb{W}'_t = \sigma \left[\pi_t + \frac{\theta_t - 1}{\theta_t}(1 - \mu_t)c_t \right] \tag{4.6}$$

The expression in equation (4.6) is more tractable for the model, and does not take away from those elements discussed above. On the contrary, it provides a clear indication as to how market imperfections and strategic interactions affect welfare losses. First,
30 welfare losses are proportional to households risk aversion, as captured by parameter σ. This expression is similar to Lucas' (2003) estimate of welfare gains from cycle-smoothing,

as well as the literature on macroeconomic policy discussed in Taylor (1999). The fact that our welfare criterion depends on consumption and markup is a continuation of the Lucas argument, namely that welfare gains are computed in relative terms to friction-free fluctuations. Second, welfare losses in our model are also affected by inflation, as is the case in the literature as well. Third, the second leg of the welfare loss expression is none other than the inverse of the open economy markup. Increased substitution between consumer goods weakens the markup, and thus decreases welfare gains. Fourth, openness to trade features prominently in our welfare estimate, as increased trade integration at the aggregate level weakens imperfect access to consumption goods, and the subsequent loss of utility for households.

Our dynamic definition of the welfare criterion means that we need to study it as a variable in its own right within our model. In order to do so, we need to specify policy instruments available to policymakers, and assess their impact on welfare, either through policy shocks - such as a monetary policy rate change- or other exogenous shocks, such as temporary changes in productivity or openness to trade. Those results form the basis of our evaluation of monetary policy in an open economy environment as defined in our framework laid out in the previous sections.

4.2   Welfare gains and monetary regimes

We apply the results in the section above to the various policy instruments available to monetary authorities, and model them after Gali & Monacelli (2005), namely, we focus on three regimes: domestic and total inflation-targeting, as well as a fixed rate regime. In order to compare the welfare effects of each regime, we simulate the model using the calibrated and estimated values for its structural parameters, listed in table 3. On the basis of these values, we run simulated results for output in our framework, and its reaction to exogenous shocks under three policy regimes. We report the effects of increased openness to trade. We also compare output behaviour when real rigidities are taken into account. All these results are reported in figure 3 below:

The results show that there are no significant differences on output for monetary policies to target domestic or overall inflation. That can be accounted for by the fact that domestic firms adjust fairly quickly to the competitive effect of imported goods. The strategic interactions implied in this pricing schedule suggest that there is rapid convergence in pricing and production for domestic firms when confronted with foreign competitors.

By contrast, output reacts differently depending on whether real rigidities are incorporated. The simulated results square with predictions made by Ball & Romer (1990). Real rigidities generate an inefficient steady-state, and bring output further below its competitive, flexible-prices level, so monetary policy can have real effects, as reported in figure

3 above. More to the point, real rigidities make output more responsive to openness to trade in comparison to the alternative case. The hump-shaped, persistent output response to a trade shock captures the full effect of equation (3.12). Strategic interactions play a significant role in this case, because they determine the pricing schedule for domestic firms. These observe prices offered by their foreign competitors, and try to mimic them in order to hold on to their profits. However doing so implies additional investment in capital, which is costly. As a result, domestic prices stray further from changes in the domestic marginal cost.

By contrast, output in a fixed-exchange rate regime is impervious to policy rate (Taylor rule) shocks, regardless of whether nominal rigidities are incorporated or not. Again, strategic interactions are key to explain price stickiness through fixed exchange rates. This policy compels domestic firms to change their prices less frequently, which detaches those from changes in the marginal costs. This price stickiness is further raised when prices for imported goods are taken into account. On the other side of the market, the output's reaction to openness to trade bolsters household demand: domestic firms face price stickiness, which is exacerbated by fixed exchange rates, so households dramatically increase their consumption of imported goods, and the resulting expansion in aggregate demand generates the simulated outcome for aggregate output.

The welfare variable specified above can be treated the same as any other macroeconomic variable in our model. Table 4 offers a welfare variance decomposition with respect to all specified exogenous shocks in the model. The table breaks down variance decomposition with respect to monetary authorities policy regimes, as well as real rigidities.

Table 4: Welfare indicator - variance decomposition.

Exogenous Shock		Trade	TFP	Demand	Markup	Policy Rate
Domestic inflation						
	Real rigidities	1.00%	8.86%	1.79%	87.47%	1.00%
	No rigidities	0.10%	8.92%	1.80%	88.18%	1.00%
Overall inflation						
	Real rigidities	0.90%	9.15%	1.78%	87.21%	0.96%
	No rigidities	0.09%	9.21%	1.79%	87.95%	0.96%

Note: Figures refer to percentages of variance attributable to an exogenous shock.

In all four configurations reported in table 4 markup shocks account for a substantial part of welfare variance. As mentioned before, the standard neo-Keynesian framework predicts that output loss with respect to the competitive, flexible-price level is due to price dispersion. Given that firms are price-setters, their markup is responsible for the decline in output, and thus a substantial share of the welfare indicator in our model.
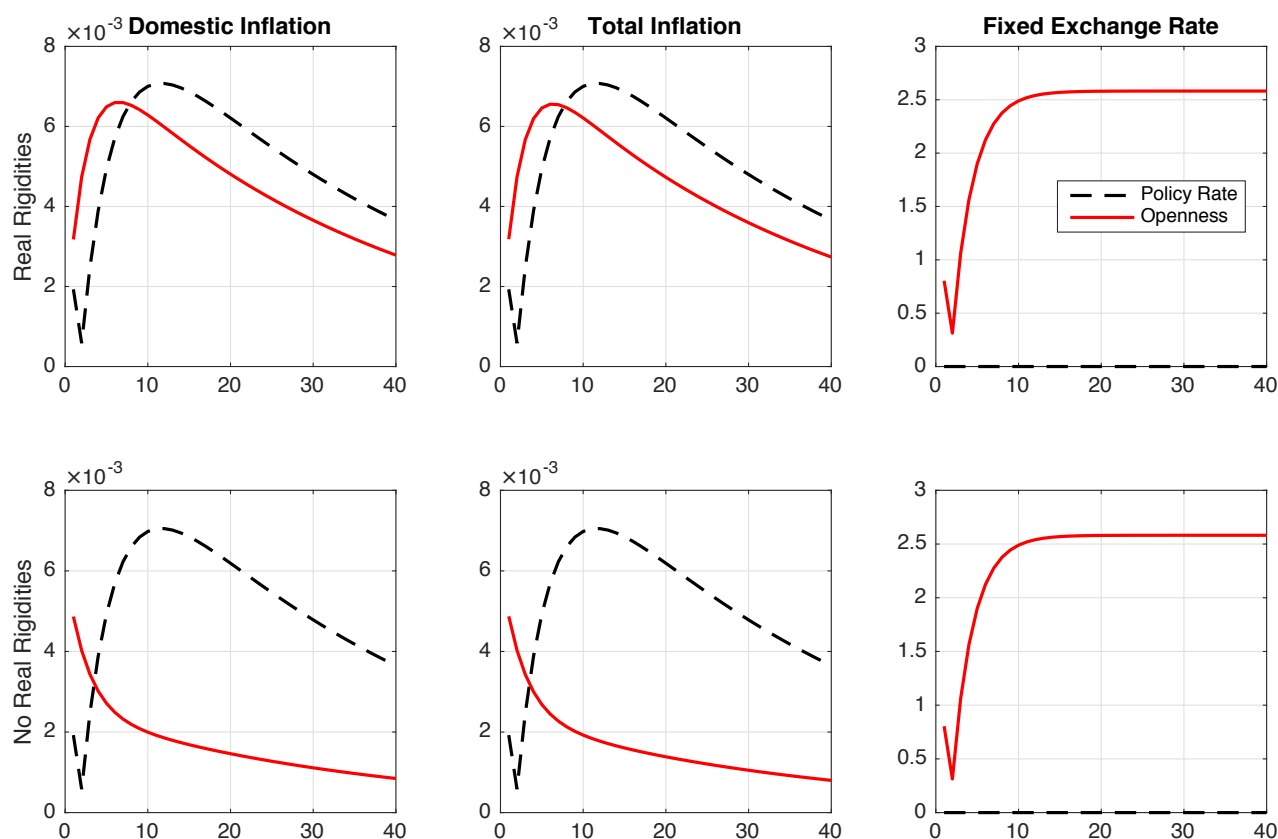
Figure 3: Output impulse response function for exogenous shocks under policy regimes and existence of real rigidities.

Although openness to trade shocks are comparatively quite low and account for a small share, they are quite sensitive to the existence of real rigidities. As shown in table 4 the contribution of trade openness in welfare fluctuations increases ten-fold when real rigidities are incorporated, which underscores the predictions made by Ball & Romer (1990).

The fact that openness to trade contributes so little to welfare fluctuations does not mean that it does not have an impact on the latter, in terms of consumption units. We show this by looking at the contemporaneous effects of openness to trade, as well as policy shocks, on the welfare criterion set out in equation (4.6). We look at its sensitivity to the existence of real rigidities, in particular when it comes to trade shocks. The model's simulated responses to exogenous shocks under alternative regimes are reported in figure 4 above. It shows that while the welfare criterion holds up to alternative specification for real rigidities, it becomes significantly more sensitive to trade shocks when the former are integrated.

The result is intuitive: under real rigidities specification, domestic production of consumption good is comparatively low, and households register a utility loss from imperfect access to consumption goods. When a trade shock occurs, there are more imported goods available on the domestic market, which means households' utility improves, while do-
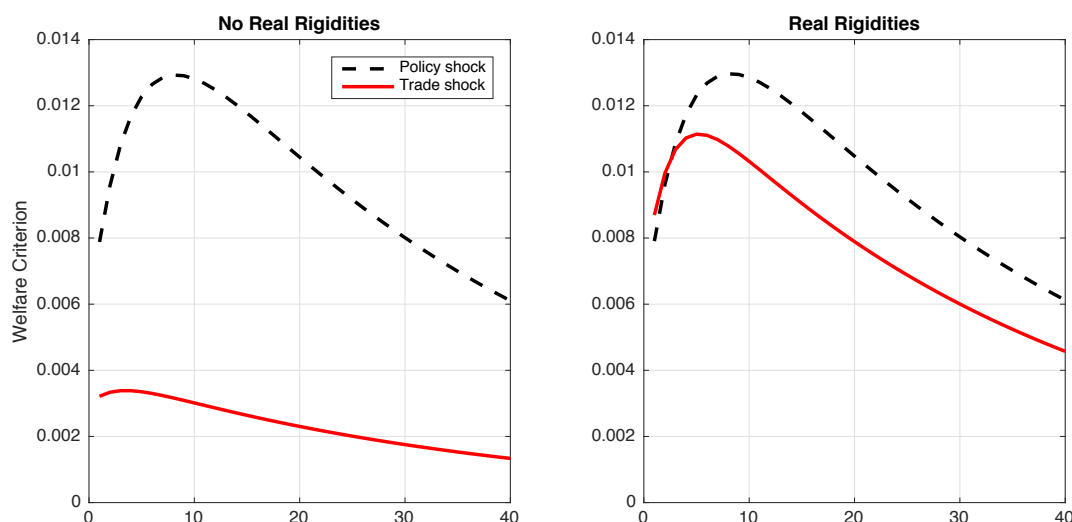
Figure 4: Welfare impulse response function for exogenous shocks under policy regimes and existence of real rigidities.

mestic firms' markup declines. Indeed, real rigidities are such that domestic firms cannot engage in strategic interactions with their foreign competitors as they want to, so their price-setting power declines in their markup. The double effect of improved access to consumption goods, as well as increased competition from foreign firms, contributes to
5 the higher sensitivity of our welfare criterion for trade shocks. Equation (3.50) captures the dynamics between domestic and overall inflations. In this equation, the gap between the two is generated by the markup effect of domestic firms, and increases proportional to the consumption loss generated by imperfect access to consumption goods. It is also contingent upon changes in the exchange rate, and indirectly, on the aggregate level of
10 capital intensity.

5   Conclusions

The neo-Keynesian framework does not adjust well to the open economy environment for several reasons: first, the literature tends to use a constant domestic bias, which may not adequately capture the implied strategic interactions between domestic and foreign firms. Second, it relies heavily on labour and wages as the sole source of production costs, and thus the only proxy for changes in marginal costs. While such an assumption is backed up by empirical claims, it is specific to large, developed economies. We have argued in this paper that firms in emerging economies face a plethora of costs that affect their production schedule, and which are not accounted for by the literature. Third, the literature relies on price stickiness as the only source of rigidities, even though Ball & Romer (1990) argued that real rigidities can go a long way in replicating nominal fluctuations as well. Fourth, the literature relies on a definition which overstates welfare gains to be expected from a particular monetary policy regime. Indeed, all computations are derived with respect to an efficient steady-state, which we have disputed in this paper. When real rigidities are included, the steady-state becomes inefficient, so a welfare criterion based on deviation from the former is likely to be biased. Furthermore, fluctuations around the steady-state cannot all be smoothed over, particular those real shocks driving fluctuations in macroeconomic aggregates. We have argued, on the basis of the computations laid out in Lucas (2003), that welfare gains computed in terms of deviation from a steady-state are bound to be over-stated. This is the case because they incorporate fluctuations that do not yield significant gains in terms of permanent consumption.

Throughout this paper, we have sought to address those shortcomings. We have replaced the constant domestic bias with a variable which captures openness to trade instead. We have linked it to domestic intermediate firms' production schedule, which lays out the micro-foundations of imperfect access to consumption goods. The paper formulates an alternative specification of the New Phillips Curve (NKPC), where inflation is not only function of the output gap, but also additional components, such as openness to trade and the markup. In addition, we also computed an alternative specification to the output gap, one that takes into account real rigidities implied in the value function of intermediate firms. The resulting forward-looking IS equation also integrates openness to trade as a proxy for the effects of foreign firms on their domestic competitors' production schedule, as well as their pricing decisions.

We have shown in this paper that the welfare criterion favoured in the literature has significant limitations when applied to open, emerging economies: it overstates potential gains from monetary policy regimes, and it relies exclusively on nominal rigidities to account for the shortfall of output with respect to its competitive, flexible-prices level. We propose in this paper an alternative specification of the welfare criterion, one based on the shortfall of intermediate demand between imperfect and full trade integration. We express

the welfare loss in consumption utility form, which is function of households' elasticity of substitution, firms' markup and openness to trade. The welfare criterion shows that the latter acquires a significant effect when real rigidities are taken into account, a feature that is more common among emerging economies than developed ones.

⁵   The results derived in this paper for the modified New Keynesian Synthesis model can be applied in a further study of monetary regimes and their welfare impact results. In particular, the capital market can be expanded in order to accommodate domestic firms' demand for investment units. Monetary policy becomes therefore more sensitive to openness to trade, since it encompasses now capital flow trade as well. As a result, ¹⁰ an inflation-averse central bank may not find the Taylor rule to be relevant, since an increase in its policy rate may actually exacerbate inflation instead. The same goes for the effects of the world interest rate, whose dynamics do not always match those set by monetary authorities in the small, open emerging economy. A global rise in interest rates for instance could hamper its openness to trade, as it makes all imported capital units ¹⁵ more expensive, and thus generate inflationary pressure at home.

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