UNIVERSITÉ DE LILLE

THÈSE DE DOCTORAT

Déterminants des Cycles économiques dans les pays émergents: Trois Essais

Business Cycles Drivers in Emerging Countries: Three Essays

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Thèse pour l'obtention du Doctorat en Science Economique, presentée et soutenue publiquement le 12 Décembre 2022

Laboratoire Clersé UMR 8019

Ecole Doctorale SESAM n°73

Declaration of Authorship

I, Atef Khelifi, declare that this thesis titled, “Déterminants des Cycles économiques dans les pays émergents: Trois Essais” and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Acknowledgements

I thank my family, my friends, my colleagues and the firms I have been working for, during the 6 years of writing of this Thesis. I have indeed worked as a Project Manager and a Data and Business Analyst.

I would like to express my deepest gratitude to my supervisor Fabien Tripier for the help I obtained in developing my ideas, models and reflexion. I also obtained help and assistance in many respects from my research center "Le Clersé", and the University of Lille.

I also thank many referees of journals, among which referees of the Journal of International Economics, the Editor Martin Uribe, referees of Economic Modelling, the editor Angus Chu, and participants to several conferences where I presented elements of my PhD Thesis.

I am finally grateful to Cécile Couharde, Professor at the University of Paris Nanterre and Jean-Christophe Poutineau, Professor at the University of Rennes 1 for having helped me clarify and improve substantially my works.

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To my family and particularly, my father.

Résumé

Les pays émergents sont confrontés à de larges fluctuations économiques. Il est donc important de comprendre les mécanismes à l'origine de cette instabilité qui pourrait constituer un frein à leur croissance et leur développement à long terme. Les cycles économiques des pays émergents diffèrent en effet de ceux des pays développés sur plusieurs aspects. Les principaux indicateurs macroéconomiques y sont plus volatils. La consommation est plus volatile que la production dans les pays émergents alors que c'est le contraire dans les pays développés. La balance commerciale est fortement contracyclique dans les pays émergents. Enfin, ces pays sont exposés à des phénomènes d'arrêt soudain (« sudden stops ») lorsque survient un brusque revirement des entrées de capitaux. L'objectif de cette thèse est de contribuer à la compréhension des mécanismes économiques à l'origine de ces spécificités du cycle économique dans les pays émergents. Le premier chapitre étudie l'hypothèse selon laquelle ces spécificités sont dues à l'occurrence de chocs de productivité permanents plus importants dans les pays émergents. En tenant compte de la préférence des agents économiques pour l'accumulation de la richesse, le rôle des chocs de productivité permanents est renforcé par rapport aux chocs de productivité transitoires dans l'explication des cycles économiques des pays émergents où « le cycle est la tendance ». Cette préférence des agents pour la richesse dans les pays émergents peut également s'expliquer par le plus faible développement des marchés financiers dans ces pays. Le deuxième chapitre examine le rôle des chocs des termes de l'échange dans le cycle économique. Ces chocs se révèlent jouer un rôle modeste dans l'explication

des cycles économiques des pays émergents. Au-delà de la question de la mesure de ces chocs, il apparaît que la structure d'entrées-sorties des facteurs de production joue un rôle clef dans leur transmission dans l'économie. Les effets expansionnistes attendus de ces chocs des termes de l'échange sont en effet atténués car les pays consomment et utilisent très souvent leurs propres produits exportés sur le marché intérieur. Le troisième chapitre porte sur le choix des indices de prix pour la mesure des chocs sur les termes de l'échange. Les résultats empiriques de ce chapitre montrent que lorsqu'un seul prix agrégé est utilisé (exemple les « termes de l'échange »), l'impact macroéconomique de ses fluctuations apparait relativement modeste. Au contraire, lorsqu'on considère un niveau plus désagrégé, avec plusieurs prix, l'impact macroéconomique de leur fluctuation devient important. Ce résultat empirique apparaît en contradiction avec les modèles théoriques de référence de la littérature où les impacts macroéconomiques des fluctuations de prix apparaissent identiques quel que soit le niveau d'agrégation. Cette conclusion appelle à l'extension de ces modèles théoriques vers la prise en compte de mécanismes de transmission supplémentaires, notamment le lien avec les frictions financières.

General Abstract

Emerging countries are confronted with wide economic fluctuations. It is therefore important to understand the mechanisms behind this instability, which could hinder their long-term growth and development. The economic cycles of emerging countries differ from those of developed countries in several respects. The main macroeconomic indicators are more volatile. Consumption is more volatile than production in emerging countries, whereas the opposite is true in developed countries. The trade balance is highly countercyclical in emerging countries. Finally, these countries are exposed to sudden stops when there is a sudden reversal in capital inflows. The objective of this thesis is to contribute to the understanding of the economic mechanisms behind these specificities of the business cycle in emerging countries. The first chapter studies the hypothesis that these specificities are due to the occurrence of larger permanent productivity shocks in emerging countries. By taking into account the preference of economic agents for wealth accumulation, the role of permanent productivity shocks is strengthened relative to transitory productivity shocks in explaining business cycles in emerging countries where "the cycle is the trend". This preference of agents for wealth in emerging countries can also be explained by the weaker development of financial markets in these countries. The second chapter examines the role of terms-of-trade shocks in the business cycle. These shocks are found to play a modest role in explaining business cycles in emerging countries. Beyond the question of measuring these shocks, it appears that the input-output structure of factors of production plays a key role in their transmission through the

economy. The expected expansionary effects of these terms-of-trade shocks are in fact attenuated because countries very often consume and use their own exported products on the domestic market. The third chapter deals with the choice of price indices for measuring terms-of-trade shocks. The empirical results of this chapter show that when a single aggregate price is used (e.g. the "terms of trade"), the macroeconomic impact of its fluctuations appears relatively modest. On the contrary, when a more disaggregated level is considered, with several prices, the macroeconomic impact of their fluctuations becomes significant. This empirical result appears to be in contradiction with the theoretical models of reference in the literature, where the macroeconomic impacts of price fluctuations appear to be identical regardless of the level of aggregation. This conclusion calls for the extension of these theoretical models to take into account additional transmission mechanisms, notably the link with financial frictions.

General Introduction

Emerging countries are known to be confronted with large business fluctuations. It is important to understand the determinants of this economic instability which is most likely damaging to long term economic growth and developpment. In the literature, two main approaches compete to explain specific characteristics of business fluctuations of emerging countries which differ in many respects from those of developed countries. A detailed description of business cycles is for example presented in Aguiar M. and Gopinath G. (2007), Table 1 and 2. Several empirical regularities are clearly identified. In particular, emerging countries experience:

- a larger volatility of macroeconomic indicators, namely, output, consumption, investment and the trade balance-to-output ratio
- a higher volatility of consumption relatively to output (40% more)
- a strong counter-cyclicality of the trade balance
- "sudden stops" (in the sense of sudden reversals in net capital inflows).

The first theoretical approach which attempts to explain those observations follows Aguiar and Gopinath (2007), and consists in attributing the high volatility of macroeconomic variables in emerging countries to structural changes in the trend growth, rather than temporary fluctuations around a relatively stable trend as in developed countries. The idea supporting this theory relies on the fact that emerging economies are faced with frequent major policy regime switches, affecting investment and development decisions.

Based on the permanent income hypothesis, this idea allows to explain large movements in consumption relatively to output. The Friedman theory of consumption explains indeed that changes in permanent income rather than transitory income flows, are the main drivers of the consumption volatility.

The second approach contrasts with this trend shocks explanation. It points out the financial specificities of emerging countries, as being responsible for the observed business fluctuations that differ from those of developed economies. A recent contribution from Garcia-Ciccio, Pancrzai and Uribe (2010) follows this approach and shows that Aguiar and Gopinath (2007) may not be the sole possible explanation. Indeed, they explain that reducing the access of emerging countries to foreign financial markets, can also be an important source of higher volatilities that rejects the necessity to introduce trend shocks. They even show that ignoring those financial frictions in a standard RBC model, as the one presented by Aguiar and Gopinath (2007) to motivate their conclusion, implies the counterfactual result of a trade-balance-to-output ratio which follows a random walk. Empirical facts documented indeed in Garcia-Cicco et al. (2010) indicate indeed a trade-balance-to-output ratio that rapidly decreases to zero for almost all emerging economies.

Aside from those main approaches discussing the major drivers of output fluctuations, another puzzling question regarding fluctuations in emerging countries is the role of world shocks in general, mediated by commodity prices or terms-of-trade, and interest spreads. Measures of the contributions of world shocks vary significantly from a study to another. The differences rely on the nature of the models used (theoretical or empirical), the data and sometimes the size of samples, the type of shock transmitter, the structural assumptions in general, and the measure of theoretical counterparts of observed macroeconomic variables.

The goal of this PhD thesis is to contribute significantly to the understanding of the main drivers of business cycles in emerging countries, and to shed light precisely on those complex and controversial issues. We devote three chapters. The first one addresses the question of trend versus temporary productivity shocks regarding the explanation of the higher volatility of consumption relatively to output. The second investigates the role of terms-of-trade shocks in business fluctuations of emerging countries. The third one answers the question of which kind of shock transmitter to use when studying effects of world disturbances. Along chapter two and three we also introduce a new multi-sector DSGE model of a small-open economy (SOE) developed on the basis of the structure of input-output data. It presents the advantage of a great simplicity though it consists in a microeconomic dynamic foundation of the input-output methodology.

Chapter 2: Wealth preference and consumption volatility in emerging countries

In the first chapter, I address the role of trend shocks and financial frictions in economic fluctuations in a small open economy model where individuals derive utility from holding wealth; e.g. Bakshi and Chen (1996) or Kumhof, Ranciere and Winant (2015). My premise is that this assumption which already helped reconcile several empirical facts with theory, could eventually improve understanding of business cycles of emerging and developed countries. The idea is that individuals in real life, can save money for many reasons that have nothing to do with own consumption deferred in the future, or with the discounted rate of return. Motivations are mainly sociological, like the desire to gain power, to increase social status, to give, to bequeath or transfer wealth to children (eventually in the form of physical capital). I formalize such motivations directly in the utility specification and consider two alternatives. In a first specifiation, individuals are assumed to value their stock of wealth. In a second one, individuals are supposed endowed of a direct preference thriftiness; i.e., a direct preference for saving a part of income each time for social reasons. The analysis of a utility function involving a preference for wealth is interesting in that context, because the mathematical implication of this hypothesis is that agents desire to smooth both consumption and capital. As an expected consequence, the volatility of consumption should increase to the detriment of the volatility of investment. This might eventually help understand better one of the most puzzling empirical regularity cited previously, the high consumption-output volatility.

Along a simulation exercise first, I analyze the role of this augmented utility function through the impulse response functions and the behavior of second moments. Two important results arise. First, the higher the preference for wealth is, the higher the volatility of the consumption-output ratio as expected. This is an interesting result because it sounds in contradiction with the theory of wealth-in-utility, where the high preference for capital accumulation is a characteristic that belongs to rich individuals and countries. The second important result is the direct consequence of this property in the theoretical framework of GPU, where contrary to the one of AG, the ratio of consumption to output becomes less volatile as the relative size of the permanent shock increases. Indeed, it turns out finally that the presence of a direct preference for wealth implies potentially a higher size of the permanent productivity shock, which appears confirmed by estimations of the model on same data, using same Bayesian techniques. I then perform several robustness checks, and conclude that the hypothesis that the cycle is the trend, suggested by Aguiar and Gopinath (2007), remains entirely valid for the explanation of economic cycles of developing countries.

Chapter 3: World Prices and Business Cycles of a Small Open Input-Output Economy

In this chapter, I focus on external shocks and precisely on the role of terms-of-trade shocks, which are known in the literature as a major source of business fluctuations since Mendoza (1995) and Kose (2002). Nonetheless, a recent empirical study of Schmitt-Grohe and Uribe (2018) on 38 countries challenges this conventional wisdom and shows that terms-of-trade shocks plays actually a small role in the explanation of business fluctuations of emerging countries (12%). They also strengthen their result by showing through the lens of a DSGE model, that once theoretical variables are measured in same units as in the data (and for instance deflated in a same way), the major impact of terms-of-trade is significantly reduced. They indeed find that on average, the theoretical model confirms the SVAR predictions. However, the question of the role of terms-of-trade shocks is not completly answered. At the country-by-country level, there remain large differences between theoretical and empirical predictions which have to be understood. Specifically, the theoretical predictions tend to over-estimate responses to terms-of-trade shocks.

This disconnect problem might be resolved either by dampening the theoretical effects of terms-of-trade shocks or by increasing the empirical effects related to shocks on world prices as advocated by Fernandez, Schmitt-Grohe and Uribe (2017). In this paper, I focus on how to mitigate theoretical over-prediction of macroeconomic fluctuations. I study this question through an alternative multisector SOE model, with a structure replicating the one of input-output data tables. I calibrate and estimate the model and show that the global demand structure constitutes an important dampening transmission channel of terms-of-trade shocks. Indeed, in the literature, models tend to under-estimate this channel and to concentrate the main transmission on the supply side with an export sector encouraged to produce more. Actually, the increase in the price of a domestic product comes also with an increase of production and consumption price indexes (under limited possibilities to substitute), which both discourage production in all the remaining sectors of the economy.

The overall impact of a terms-of-trade shock is therefore the result of two opposite effects that can dominate or compensate each other. We find for instance that the proposed model explains better the different impacts of terms-of-trade shocks across countries and attenuates impulse responses. As a conclusion, I confirm and support the conclusion of Schmitt-Grohe and Uribe (2018) about a minor effect of terms-of-trade shocks, contrary to conventional wisdom.

Chapter 4: Terms of Trade or Multiple World Prices ? A Theoretical Analysis of Business Cycles

In another recent empirical study based on 138 countries, Fernandez, Schmitt-Grohe and Uribe (2017) show that world shocks mediated by multiple commodity prices explain a large fraction of business cycles of a domestic economy (33%). They conclude therefore that a single price index used as a transmitter of world shocks (like terms-of-trade), leads to under-estimate their impact on business cycles for statistical reasons. They explain that "the channel through which world shocks transmit into domestic economies is much richer than the one that can be captured by a few highly aggregated measures of world prices." They also add that it would be interesting to extend their analysis by estimating versions of the SVAR model with a disagregation of the three categories of commodity prices into finer components. I propose to investigate the role of multiple commodity prices in business cycles of Argentina through the lens of a theoretical DSGE model.

The proposed analysis through a DSGE model has for goal to check whether empirical results are confirmed, and if so, to the detriment of which of the other shocks commonly studied in this literature, for instance, the permanent and temporary productivity shock, the interest-premium shock and the preference shock. I rely on the model of Garcia-Cicco et al (2010) of a small-open economy (SOE) and extend it to four sectors along the structure of input-output (IO) data (model presented in chapter 2). The four sectors refer to the three commodity ones considered by Fernandez et al. (2017) and to a fourth one which represents the rest-of-the domestic economy. The model is then calibrated and estimated on annual data of Argentina from 1960 to 2011. Precisely, I use the same data on commodity prices as Fernandez et al. (2017), and same data on macroeconomic aggregates as Schmitt-Grohe and Uribe (2018) in their study of the role of terms-of-trade shocks.

Results do not confirm the important share of variance of domestic output explained by multiple world commodity prices. The estimated share of variance appears indeed extremely close to the one obtained by Schmitt-Grohe and Uribe (2018) under the single price specification of terms-of-trade (12% versus 13%.) I then explain through a simulation exercise, that fluctuations of output caused by world shocks in a theoretical DSGE framework do not depend only on the number of prices used as transmitters, but also on the level of aggregation of sectors. I confirm through this exercise that agregating sectors and prices do not imply a lower impact of price shocks in comparison with the disagregated configuration. As a consequence, there is a clear disconnect between empirical and theoretical predictions; i.e, on the theoretical side, predictions converge for the multiple and single price specification, and on the empirical side, predictions diverge.

Two potential explantions can be proposed. On the empirical side first, there might be a statistical problem of bias. If not, then the theoretical model is lacking a mechanism that should amplify the role of commodity price shocks; the literature commonly admits for example that the commodity price varaition is related to the level of risk of the country. The theoretical model can therefore be augmented by including a commodity price effect on the real-excahnge rate or the external debt interest rate. Such an amplifying mechanism would not apply for terms-of-trade shocks (less 'visible' by financial actors). This would explain the different empirical predictions regarding the role of commodity price and terms of trade, meaning therefore that it would not be a statistical matter of agregation and single price specification as suspected by Fernandez et al. (2017).

1 Wealth preference and consumption volatility in emerging countries

The role of trend shocks and financial frictions in driving economic fluctuations in emerging economies is revisited in a context where individuals derive utility from wealth. The underlying premise is that scarcity of wealth in poor countries rhymes with limited access to credit, high interest rates and banking fees, implying therefore that individuals tend to fend for themselves to accumulate capital. The suggested type of preference induces a mechanical effect of capital smoothing so that in response to a productivity shock, the consumption-output ratio fluctuates more than in the case of no preference for wealth, and the investment-output ratio fluctuates less. I argue that it could help explaining the well-kown excess volatility of consumption relatively to output, and analyse quantitatively the implications of this assumption in the theoretical framework of Garcia-Cicco et al (2010). I conduct estimations on same Argentine data (from 1900 to 2005) and obtain results that challenge their influencial conclusion rejecting the hypothesis of Aguiar and Gopinath (2007) that 'the cycle is the trend'.

1.1 Introduction

An important current topic in macoreconomics is one that studies business cycles of small open economies, and more precisely, the reasons for the observed differences among rich and poor countries widely documented in the literature (see for example Aguiar and Gopinath (2007), henceforth AG, or Garcia-Cicco, Pancrazi and Uribe (2010), henceforth GPU). Notably, the most intriguing characteristics of business cycles is the higher volatility of consumption relatively to income, and the strong counter-cyclicality of the trade balance in almost all emerging countries.

Several theories compete to explain these phenomenon in the literature. On the one side, attention is given to different types of disturbances of relative importance, like for example permanent productivity (or trend) shocks, as in AG, which are motivated by the frequent regime switches in economic policies and market failures faced by poor countries; other examples of shocks in the literature are ones that affect the interest rate, terms-of-trade or commodity prices, the time-preference, government spendings, etc. On the other side, many authors concentrate on amplifying phenomenon of the various disturbances, like for example the presence of financial frictions, the structure of the economy itself, expectations, imperfect information, reactions of financial markets, etc. According to GPU for instance, an extension of the RBC model of AG that includes financial frictions and supplementary random shocks, appears more appropriate to fit the data, and in particular, the volatility and autocorrelation of the trade-balance-to-output ratio. Using Argentine data over the period 1900–2005 (a larger sample than AG arguably more appropriate), they indeed show that their extended model performs better and predicts that trend shocks play actually no significant role in explaining economic cycles.

I propose to contribute to this literature by studying the implications of a direct preference for wealth in the utility function of individuals, which is motivated by the presence of credit frictions. Indeed, the underlying premise is that scarcity of wealth in poor countries, lacks of collaterals, high interest rates, and paid-for financial services, tend to make individuals strive to accumulate sufficient wealth by their own, in order to invest and to escape poverty. The seek for capital for its own sake in that case, can therefore be formalized by a direct preference for wealth, which would be more important in emerging countries than in developped ones where obtaining credits is relatively easier. A main reason why such an asumption might be interesting to investigate is straightforward. When capital enters the utility function, individuals attempt to smooth a combination of consumption and capital, where the higher is the weight on capital, the lower is the "need" to smooth consumption. Consequently, in response to a shock, consumption fluctuates more than in the case of no preference for capital, and investment fluctuates less. In other words, the implied economic dynamics corroborates the excess volatility of consumption observed in emerging economies.

Two branches of the literature are joined in this paper. The first one studies the effects of a direct preference for wealth. This assumption finds different types of motivation. In one of the seminal papers, Zou (1994), a direct preference for the stock of capital is introduced to formalize the spirit of capitalism of Max Weber (1930). The idea is that individuals, as investors, differ in terms of preference for wealth accumulation for sociological reasons (social status, influence, etc.), and this difference among individuals or countries helps understanding empirical growth facts that the standard model fails to explain; for instance differences in terms of income and growth rates across countries (every 'standard' parameters equal). In Caroll (2000), consumers are also supposed to regard the accumulation of wealth as an end in itself, and derive utility from wealth for the flow of services it provides. The author argues indeed that it seems the only way to explain the saving behavior of wealthy individuals. In many other papers, e.g. Kumhof and Ranciere (2015), Michau (2018) or Michaillat and Saez (2021), the wealth-in-utility assumption appears relevant to understand the data and is often motivated in a same way, that is, rich individuals take care about social status and power. However, no real evidences support the idea that the preference for wealth belongs to rich individuals specifically. In the meantime, other motives that justify this type of preference can be found in the joy-of-giving literature or in models of inheritance, where altruistic indivduals derive utility from giving and bequeathing; e.g. Dynan, Skinner and Zeldes (2002) or Khelifi (2016). In other words, poor individuals can also derive utility from accumulating wealth. It is even plausible to suggest that under scarcity of capital, individuals in poor countries value more a marginal unit of capital than individuals in developped countries. Following this idea, I propose to link this literature to the one of business cycles in small open economies to investigate whether this type of preference (and its implications explained previously), shed further light on the debate about the excess consumption volatility observed in poor countries.

In this second branch of the literature studying business cycles, several propositions have been made since Garcia-Cicco et al. (2010) to explain why consumption is more volaltile than income in emerging countries. Most of them explore amplifying pheomenon of financial frictions like for example, Neumeyer and Perri (2005) with the presence of a working capital borrowing constraint, or De Resende (2006) with the presence of endogenous borrowing limits. Other proposals have suggested to account for durable goods which provide utility over time, like for example Alvarez-Parra et al. (2013). The search for explanations has even been adressed through the study of changes in the volatility of the interest rate (i.e, volatility shocks) as in Fernandez-Villaverde et al. (2009). In this paper, I propose an alternative way that has not been investigated yet. I extend the standard framework of Garcia-Cicco et al. (2010) to include a preference for wealth in a context of credit frictions, and show that it leads to significant changes in estimations of all underlying shock processes using the same Argentine data, implying in consequence a different lecture of the mechanisms behind the macroeconomic dynamics. Our conclusion support for instance the relevance of permanent shocks and confirms therefore results of other studies like Boz et al. (2011) under imperfect information, Naoussi and Tripier (2013) from an economic developpment perspective, or Miyamoto and Nguyen (2017) in presence of endogenous collateral constraints.

The remaining of the paper is organized as follows. Section 2 presents an extended version of the financial friction model of GPU which includes a direct preference for wealth. It also discusses the role of this assumption along a theoretical simulation exercise. Section 3 presents the estimation strategy and results of the empirical implementation of the model. Section 4 reinforces the analysis with robustness checks. Section 5 concludes.

1.2 Model

1.2.1 Producers

The theoretical framework extends the standard small open economy model of Schmitt-Grohe and Uribe (2003) to incoporate a direct preference for wealth in the utility function, which is motivated by the difficulties to access credits and by the high interest rates which characterize poor countries. The idea is indeed to investigate whether this departure in the preference structure shed further light on the debate about the relevance of transitory and permanent shocks for emerging countries. The model assumes the same standard production function as in this literature:

$$Y_t = a_t K_t^{\alpha} (X_t h_t)^{1-\alpha} \tag{1.1}$$

where Y_t denotes output, K_t denotes capital and h_t labor. The level of output is affected by two different types of shocks, a_t, denoting a temporary productivity shock and following an AR(1) process:

$$\log a_{t+1} = \rho_a . \log a_t + \epsilon_{t+1}^a; \quad \epsilon_t^a \sim N(0, \sigma_a^2),$$

and X_t, denoting a trend shock and following a non-stationary process with:

$$g_t \equiv \frac{X_t}{X_{t-1}},$$

where g_t defines the growth rate of X_t. We assume that the logarithm of g_t follows an AR(1) process of the form:

$$\log \frac{g_{t+1}}{g} = \rho_g \log \frac{g_t}{g} + \epsilon_{t+1}^g; \quad \epsilon_t^g \sim N(0, \sigma_g^2),$$

where g denotes a deterministic long run mean growth rate.

Producers borrow the capital from domestic households and financial international markets. The profit maximizing conditions are standard with a marginal productivity of capital remunerated a gross interest rate u_t , and a marginal productivity of labor remunerated w_t.

1.2.2 Households

The aggregate utility function of the GPU model is extended to incorporate a direct preference for wealth. It is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \nu_t \frac{\left[C_t + \tau K_t - \theta \omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma} \tag{1.2}$$

where C_t denotes consumption, h_t denotes labor, and X_t denotes a productivity process (required to ensure the stationnarity of labor supply). The parameters τ and θ refer to positive weights given respectively, to capital and to labor effort in terms of preference (note that τ is supposed to be high in poor countries and low in developped ones). The parameters ω and γ serve to measure, respectively, the wage elasticity of labor supply, and the intertemporal elasticity of substitution. The model assumes a preference shock process:

$$log\nu_{t+1} = \rho_\nu.log\nu_t + \epsilon^\nu_{t+1}, \quad \epsilon^\nu_t \sim N(0, \sigma^2_\nu).$$

Households can contract one-period non-contingent debt on financial international markets with price:

$$\frac{1}{q_t} = (1 + r_t) + e^{\mu_t - 1},$$

where r_t is the interest rate (precisely, a world interest rate plus spread). To ensure stationarity, for instance a steady-state independent from initial conditions, we assume that the country faces a debt-elastic interest premium as in Schmitt-Grohé and Uribe (2003). Precisely, the country pays its contracted debt the world interest rate r^* plus a strictly positive premium depending on its level of debt

$$r_t = r^* + \psi(e^{\tilde{D}_{t+1} - D} - 1),$$

where ψ denotes a premium elasticity parameter and $\tilde{D}_{t+1}$, the agregate level of external debt per capita that households take as exogenous (D being the steady-state level). We let μ_t denote an exogenous premium shock supposed to follow an AR(1) process also:

$$log\mu_{t+1} = \rho_\mu.log\mu_t + \epsilon^\mu_{t+1}, \quad \epsilon^\mu_t \sim N(0, \sigma^2_\mu).$$

The intertemporal resource constraint is given by:

$$q_t D_{t+1} + w_t h_t + u_t K_t - \delta K_t = D_t + C_t + K_{t+1} - K_t + \frac{\phi}{2} \left(\frac{Kt+1}{K_t} - g \right)^2 K_t + \xi K_t \tag{1.3}$$

where D_t denotes the level of external debt and ϕ denotes an elasticity parameter associated to the capital adjustment cost. Households are subject to a no Ponzi constraint, with:

$$\lim_{j \to +\infty} E_t \left(\frac{D_{t+j}}{\Pi_{s=0}^{j} (1+r_s)} \right) \leq 0.$$

The GPU model is also extended to include an amount ξK_t which can be interpreted as a reduced form of credit frictions motivating the direct preference for wealth of individuals. It can consist for example in a cost of provision of capital coming in addition to the adjustment capital costs (i.e., it "consumes" or costs resources to obtain credits and to adjust capital). It can also be interpreted as a borrowing constraint implying a level of investment below the total amount of savings (it is indeed the case for Argentina according to data provided by the FED of St-Louis). At first glance, it seems not necessary 'mathematically' to introduce this specific parameter which appears to play the same role as the rate of depreciation in the equation. However, it is actually worth dissociating δ from ξ , to obtain the possibility to calibrate the saving and investment-output ratios separetly; the gap between those two ratios can differ significantly from a country to another.

Letting $\lambda_t X_{t-1}^{-\gamma}$ denote the lagrangian multiplier, we can express the lagrangian associated to the households program as follows:

$$L = E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \left[\frac{\left[C_t + \tau . K_t - \theta \omega^{-1} X_{t-1} h_t^{\omega} \right]^{1-\gamma} - 1}{1-\gamma} \right.$$

$$+\lambda_t X_{t-1}^{-\gamma}\left[q_t D_{t+1} - D_t + Y_t - C_t - K_{t+1} + (1-\delta)K_t - \xi K_t - \frac{\phi}{2}\left(\frac{Kt+1}{K_t} - g\right)^2 K_t\right]$$

Taking as given initial conditions K_0 and D_{-1}, stochastic processes a_t and X_t, and the interest rate r_t, households seek to maximize this expression over C_t, h_t, D_{t+1} and K_{t+1}. It is interesting to present some elements of the resolution (detailed in appendix), and for instance, the modified Euler equation and the steady-state equilibrium level of capital in stationary form. Indeed, the combination of the first order conditions with respect to C_t, and D_{t+1} leads to the following rule (in stationary form):

$$\frac{\partial U_t}{\partial c_t} = \frac{\beta}{g_t^{\gamma}} E_t \frac{\partial U_{t+1}}{\partial c_{t+1}}(1 + r^* + \psi(e^{\tilde{D}_{t+1}-D} - 1) + e^{\mu_t - 1}) \tag{1.4}$$

where it appears clear that the less the country is faced with financial frictions (through a low level of ψ) the more it can smooth consumption by borrowing when affected by productivity shocks. This standard Euler equation applies also to capital in our framework with:

$$\frac{\partial U_t}{\partial k_t} = \tau \frac{\partial U_t}{\partial c_t}. \tag{1.5}$$

This equation is introduced in the dynamics when simplifying the first-order condition with respect to $kt+1$. In the detailed resolution presented in appendix, we indeed let

$$\frac{\partial U_t}{\partial k_{t+1}} = \lambda_{t+1}\tau.$$

A direct implication of the supposed utility function, is therefore that households desire to smooth a combination of consumption and capital, meaning that it is reasonable to expect a lower volatility of investment, and hence in return, an increase in variability of consumption. The presence of a wealth preference for capital modifies also the investment decision rule with a higher incentive to invest compared to a case with no wealth preference. It turns out that the steady-state capital is increasing in the weight τ attributed to capital in the utility function :

$$\frac{k_t}{g_t h_t} = \left(\frac{\alpha}{g^{\gamma}/\beta - 1 + \delta + \xi - \tau} \right)^{1/(1-\alpha)} \tag{1.6}$$

This weight balances the proportion ξ which captures the expensiveness of banking services and plays therefore a dissuasive role in capital accumulation.

1.2.3 The role of a direct preference for wealth

It is judicious to perform a simulation exercice to get some intuition about the impacts of the preference for wealth introduced. For this purpose, we can recall the calibrated and estimated values of the parameters from GPU and set arbitrary values for the two additionnal parameters τ and ξ (let $\tau = 0.05$ and $\xi = 0.02$). The pertinent variables on which to concentrate are output, and ratios of consumption, investment, and net exports to output.

In Figures 1.1 and 1.2, we confront impulse response functions (IRF) that result from the different shocks considered by GPU. We display results by dissociating two cases. The first one departs from GPU and assumes $\xi = 0.02$ and the second one assumes $\xi = 0.02$ and $\tau = 0.05$. Several aspects are worth underlying. The volatility of consumption and investment relatively to output are significantly affected by the presence of credit frictions and the utility wealth effect. For each type of productivity shock, the consumption-ouptut ratio is higher than in the standard GPU model. Precisely, the utility wealth effect amplifies the increase of the consumption-output ratio due credit frictions, especially in the case of a temporary productivity shock. In parallel, the utility wealth effect offsets the impact of credit frictions on the investment-output ratio (partially in the case of a temporary shock). Concerning the response of the trade balance to output ratio, it is drastically dampened in the case of a temporary shock, and slightly affected in the case of a trend shock. In Figure 1.2, the dynamics resulting from an interest shock or a time preference shock are influenced by the presence of credit frictions only. The utility wealth effect plays indeed no role in view of the small marginal effect on responses under credit frictions. In the case of an interest rate shock, the investment-saving gap tends to attenuate the negative dynamics of investment and output. In the case of a time preference shock, the decline in investment and output is amplified.

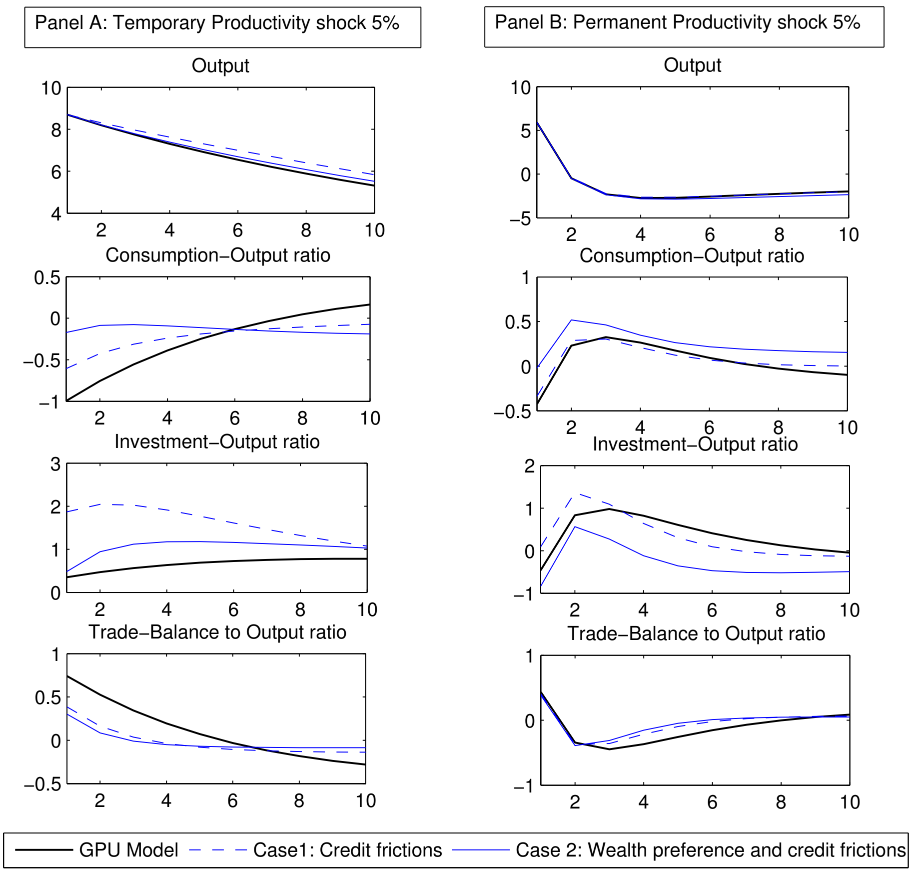

FIGURE 1.1: Impulse responses following a 5% Productivity shock

Note: Panel A presents impulse responses to a 5% temporary shock and Panel B, impulse responses to a 5% permanent shock.

Another way to get more insight on the impact of a preference for wealth is to analyze the behavior of second moments as a function of the relative size of the different types of shock. In Figures 1.3 and 1.4, we plot the main second moments of the consumption-output ratio (in terms of growth rate), the

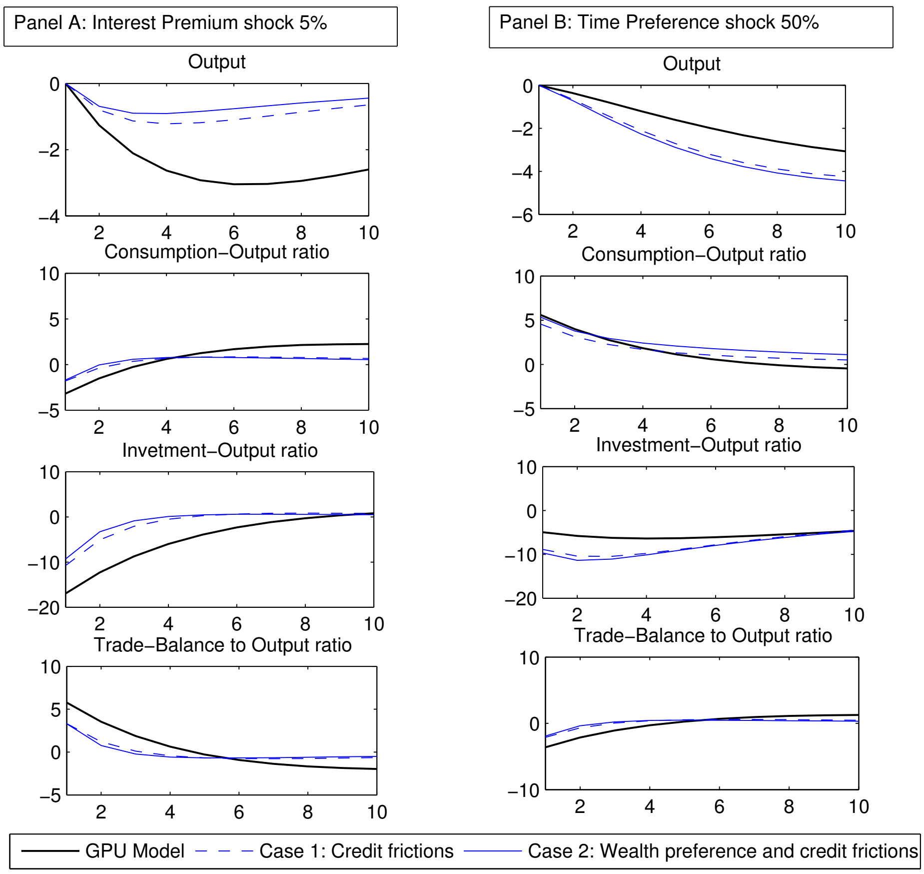

FIGURE 1.2: Impulse responses following an interest shock and a time preference shock

Note: Panel A presents impulse responses to a 5% interest shock and Panel B, impulse responses to a 50% time preference shock (the size of shocks are close to the estimated ones in GPU).

investment-output ratio, and the trade balance to output ratio resulting from the different types of shocks. We compare second moments of the standard GPU model and the extended version including credit frictions and a direct preference for wealthWe maintain the value of 0.05 for τ and the value of 0.02 for ξ and consider all other parameters fixed to the calibrated and estimated values of GPU. In each case, second moments are calculated as a function of the size of the structural shock in consideration. The moments are also compared to the estimated value of GPU and to the real value given by the data (values are represented by straight lines in red).

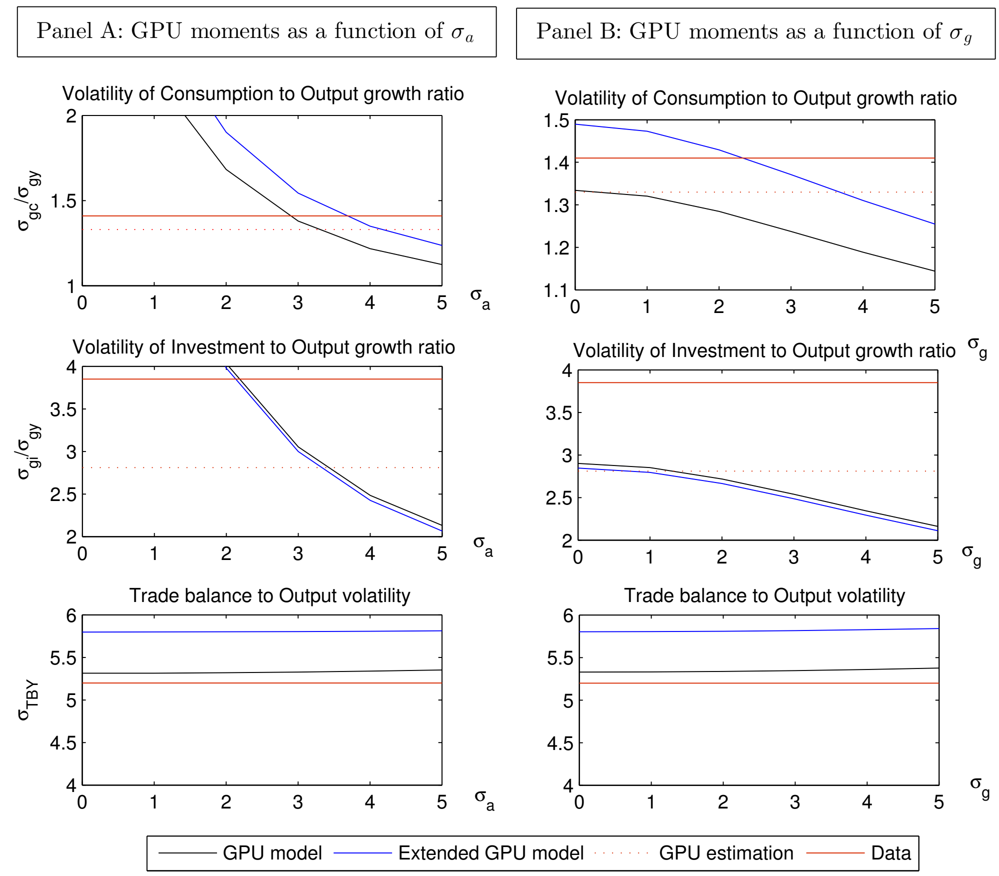

FIGURE 1.3: Second Moments as a function of σ_a and σ_g
Note: Moments are calculated based on the calibration and estimation of GPU. For each type of shock, simulations are made holding other shocks fixed to their estimated values.

First, an important and expected result is confirmed: the degree of preference for wealth increases the relative volatility of the consumption-output ratio for any type of shock. The curve representing the ratio of second moments is indeed shifted upward compared to the standard GPU case. It means that in the literature studying business cycles, a high degree of preference for wealth makes second moments move in the direction of what we observe for 'poor' countries. This is indeed interesting since in the literature of wealth-in-utility, the high preference for wealth formalizes the spirit of capitalism and tends to be assimilated to rich individuals and countries; ie, the more it is high, the richer the individual or country. However, as explained in introduction, there is no real evidence which support this conventionnal idea which seems to arise simply from static properties of the steady-state.

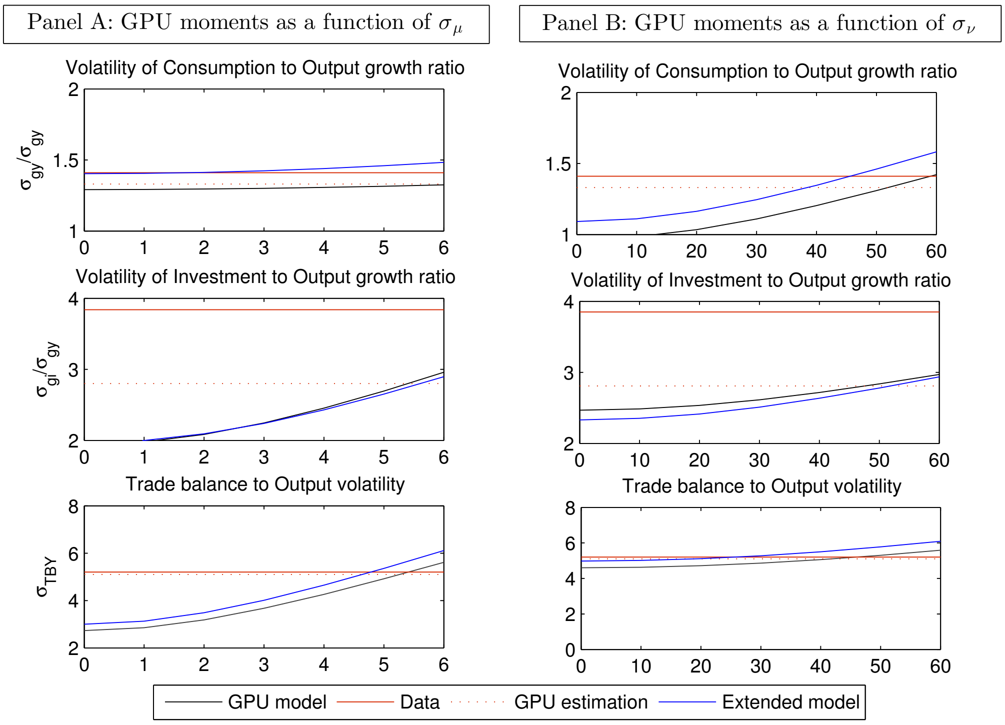

FIGURE 1.4: Second Moments as a function of σ_μ (interest shock) and σ_ν (preference shock)

Note: Moments are calculated based on the calibration and estimation of GPU. For each type of shock, simulations are made holding other shocks fixed to their estimated values.

Second, accouting for a wealth preference in the model can plausibly imply a higher size of the relative volatility of the permanent shock. Actually, for both types of productivity shock, the curve representing the value of the ratio of consumption to output volatility shifts to the right, meaning that one of the productivity shocks could eventually be under-estimated when omitting the preference for wealth. Expecting a higher size of both shocks under a new estimation of the model in the presence of the wealth effect can indeed be excluded, since it would imply an over-prediction of the response of output. Hence, the estimated productivity shocks would necessarily move in opposite direction (if impacted). The size of the permanent shock is already extremely low (i.e; slightly below 1%) to let us expect a further decrease. In the meantime, a higher temporary productivity shock means reducing further the level of investment-to-output volatility which is already largely under-estimated (real data, represented by the red line, shows a value close to 4 versus an estimation below 3 represented by the dashed red line). Increasing indeed the value of the temporary productivity shock means moving to the right along the blue curve. Hence, if estimations were to be affected by the introduction of a wealth preference in the model, one could reasonably expect that the permanent shock would most likely increase to the detriment of the temporary shock.

The size of each type of productivity shock does not change the volatility of the trade balance, as indicated by the straight balck and blue lines representing levels of second moments for different size of productivity shocks. However, the volatility of the trade-balance to output ratio appears increased with the presence of a utility-wealth effect (the straight black line shifts upward towards the blue line as the preference parameter τ changes from 0 to 0.05) . A new estimation would therefore require to reduce the volatility of this indicator. When looking at figure 1.4, it seems clear that the size of the interest shock could be the adjusting variable in that case (decreasing the size of the interest rate shock attenuates indeed the volatility of the trade-balance-to-output ratio). The time preference shock influences essentially the consumption-output ratio, and has been introduced by GPU to capture the excess consumption volatility. Under the hypothesis of a higher size of the trend shock compensated by a lower size of the transitory shock, the consumption-output ratio would be increased and hence, the size of the time preference shock could eventually be reduced in turn.

To complete this simulation exercise, we can finally take a look at the autocorrelation function of the trade balance-to-output ratio under the proposed model extentions. This function is known to be essentially shaped by the degree of financial frictions ψ. It can be shown also that the first autocorrelation coefficient remains flat as the size of any type of shock considered in the model increases (see in appendix). Under the proposed extensions, the autocorrelation function shifts downward.

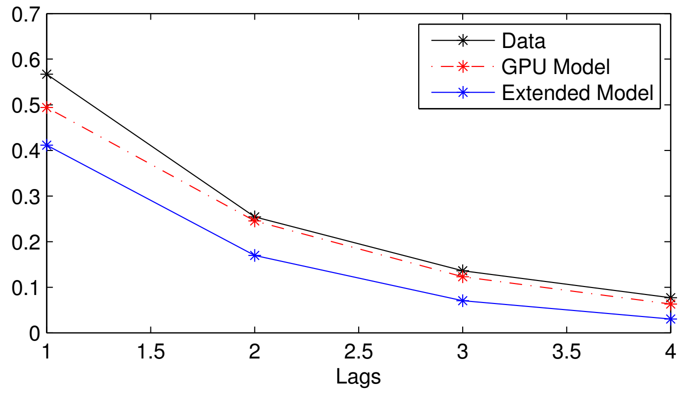

FIGURE 1.5: Autocorrelation Function of the trade-balance-to-output ratio
Note: Extended model refers to the GPU case with τ and ξ set respectively to 0.05 and 0.02..

1.3 Estimation and empirical evaluation: Argentina 1900-2005

1.3.1 Calibration of the model

Parameters implied in the determination of steady-state levels are calibrated and the remaining ones which affect only the dynamics are estimated. The presence of τ and ξ implies some slight changes with respect to the calibration of GPU, but nontheless in a way to bring the calibration closer to real data. Table 1.1 summarizes the calibration of parameters. For instance, we consider standard values of the literature for some parameters like $\gamma = 2$ for the curvature of the utility function, $\omega = 1.6$ to ensure a labor income elasticity of 1.7, $\theta = 2.24$ to obtain agents allocate 20% of their time to work, a capital income share $\alpha = 0.32$ and a depreciation rate $\delta = 0.1$. The value of β is calibrated as GPU to imply a high interest rate which is plausible for Argentina on the sample period (slightly above 8.5%, depending on the value of g). We deduce $\tau = 0.065$ so as to approach the consumption and investment-output ratios which are equal respectively to 19% and 73%. The parameter ξ is set to 0.02 to ensure a level of investment of approximately

82% of total deposits (based on data provided by the FED of St-Louis)[1]. Following AG, we calibrate D^* on the basis of the observed external debt to output ratio which corresponds according to the World bank data to 45% on the period 1970-2005; i.e. $D^* = 0.14$. We note that the implied steady-state trade-balance-to-output ratio of 4% under this value of D^* remains far below the acceptable upper bound. The data indicates indeed an average of 0.25% with a high standard deviation of 5.1% on the period 1900-2005 (attributable to the frequent policy regime switches). The main improvements versus GPU rely on the consumption-output ratio which equals 81% in their configuration (versus a real ratio of 73%), the investment-saving (or -desposits) ratio which equals 100% (versus 82% according to the FED), and finally, the sovereign debt-to-GDP ratio which equals 3% in their case (versus a real level of 45% from 1970 to 2005). They indeed calibrate D^* at 0.007 to target the average trade-balance-to-output ratio of 0.25%; section 2.4 will address results of some robustness checks using exactly the same calibration as GPU.

TABLE 1.1: Calibration

Parameter	Value	Source/Target	Calibrated value
Utility CES parameter	$\gamma = 2$	Garcia-Cicco et al. (2010)	
Depreciation rate	$\delta = 0.1$	Aguiar-Gopinath (2007)	
Share of capital	$\alpha = 0.32$	Garcia-Cicco et al. (2010)	
Labor elasticity parameter	$\omega = 1.6$	Income Elasticity	1.7
Preference parameter (labor)	$\theta = 2.24$	Share of time worked	20%
Time preference	$\beta = 0.92$	$r_t = 8.5\%$	$\geq 8.5\%$
Steady-state external debt	$D^* = 0.14$	D*/Y=45%	45%
Degree of preference for wealth	$\tau = 0.065$	$(\frac{c}{y}, \frac{i}{y}) = (0.73, 0.19)$	(0.72,0.21)
Rate of credit to deposits	$\xi = 0.02$	$\frac{I}{S} = 82\%$	85%

Note: Calibrated values are estimated under a parameter $g = 1.015$ (i.e, the median of the prior intervall). The estimated posterior median will also appear close to this value with 1.018.

[1]The ratio of bank credit to bank deposits in Argentina reported by the FED of St Louis equals indeed 82% on average over a relatively large period of 57 years

1.3.2 Bayesian estimation

We estimate all remaining parameters :

$$\Omega = \left[g, \psi, \phi, \rho_g, \rho_a, \sigma_g, \sigma_a, \rho_\mu, \sigma_\mu, \rho_\nu, \sigma_\nu\right],$$

using Bayesian methods. Given a prior $p(\Omega)$, the posterior density of the model parameters, Ω, is given by:

$$p(\Omega|Z^T) = \frac{L(\Omega|Z^T)p(\Omega)}{\int L(\Omega|Z^T)p(\Omega)d\Omega}$$

where $L(\Omega|Z^T)$ is the likelihood conditionnal on observed data $Z^T = (Z_1, ..., Z_T)$, where $Z_t = (Z_{1t}, Z_{2t}, Z_{3t}, Z_{4t})$ refers to the set of observed variables at time t, with Z_{1t} denoting the growth rate of output at time t, Z_{2t}, the growth rate of consumption, Z_{3t}, the growth rate of investment and Z_{4t},the trade balance-to-output ratio. We use the sample of Argentine data constructed by GPU on the period 1900-2005.

Posterior statistics are based on a Metropolis-Hasting algorithm of two million replications, from which the first million draws is discarded. Details are available in appendix with a Brooks and Gelman's convergence diagnostics based on two chains. We also estimate the standard deviations of measurement errors on observable as in GPU and keep the same prior (uniform) distributions for all estimated parameters.

1.3.3 Results

The approximated posterior distributions are displayed in Figure 1.6. Parameters are well identified in the data. Starting from uniform priors, the approximated posteriors peak at computed modes located significantly away from zero, and for instance at the extremum of 'well-shaped' likelihood functions. This gives a clear evidence for stochastic disturbances affecting both temporarily and permanently productivity, but also the interest rate and the time preference. The posterior distribution of the debt premium elasticity parameter is skewed but displays a peak around 3 as in GPU. Estimation results are displayed in Table 1.2. The wealth-in-utility model fits globally the data slightly better than the standard GPU one according to a log-likelihood value of 614 (versus 601.58).

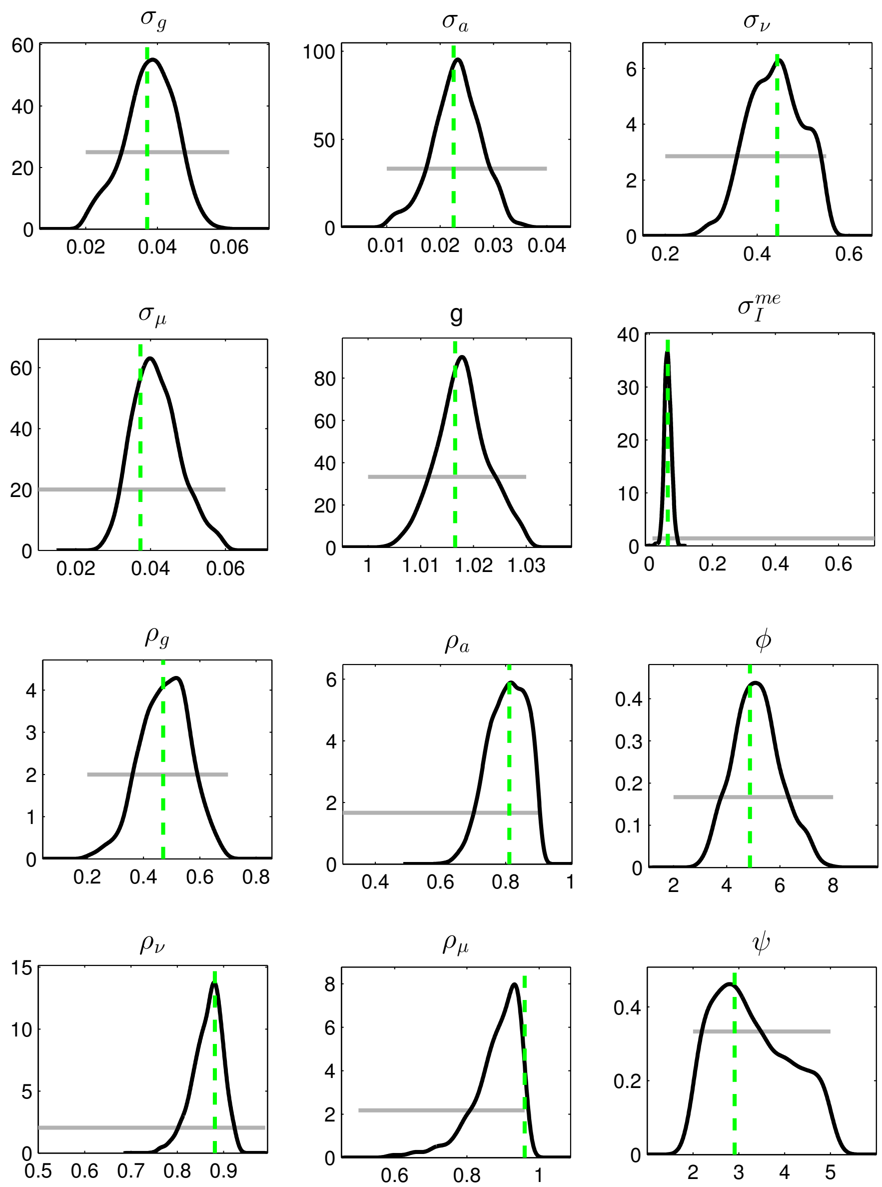

FIGURE 1.6: Posterior distributions

We note also several points in comparison with GPU. First, and most importantly, posterior medians of the nonstationary productivity shock process are relatively higher, with a volatility of 3.8% (versus 0.7%) and a persistence parameter ρ_g of 0.48, lying each within a more precise intervall. The more important role assigned to trend shocks comes with a significant reduction of the size of the volatility of the stationary productivity shock as expected, with 2.3% versus 3.3% in the standard case (note that persistance of this shock remains the same however with $\rho_a = 0.8$). This result of a predominant role of trend shocks challenges the influential conclusion of GPU which contradicts the hypothesis of AG that 'the cycle is the trend'. The potential scenario examined through the simulation exercise in the previous section helps understanding the potential reasons, however, a rigorous quantitative analysis remains necessary to clarify the underlying mechanism leading to this conclusion (which is the purpose of the next section) . A second point is that the estimated size of the premium shock appears slightly lower in our case, as expected, i.e, a one standard deviation innovation in μ_t raises the interest rate at which the country borrows from the rest of the world of 4% (versus 5%). Third, the size of the time preference shock is also reduced to 44% versus 51%, with approximately the same estimated persistance. Finally, estimations of the debt premium elasticity parameter and the capital adjustment coefficient appear robust to the presence of a utility-wealth effect, with around 3 and 5 respectively.

Table 1.3 reports the predicted second moments of the wealth-in-utility model. Results are very close to those of GPU and to the data. The main characteristic moments are well-captured with the volatility of consumption growth being around 40% greater than the one of output growth. The bulk of the excess volatility of consumption is not explained anymore by the preference shock only. Under the presence of a wealth preference, the non-stationary productivity shock appears to explain a fraction of the volatility of consumption greater than the one of the preference shock; see table 1.4, which presents the variance decomposition of the wealth-in-utility model.

TABLE 1.2: Prior and Posterior Distributions

			Posterior distribution					
	Prior distribution		Model U(C,K)			Model GPU		
Parameter	Min	Max	Median	5%	95%	Median	5%	95%
g	1	1.03	1.018	1.01	1.026	1.01	1.003	1.017
σ_g	0.02	0.06	0.038	0.0255	0.049	0.007	0.001	0.027
ρ_g	0.2	0.7	0.48	0.34	0.62	0.35	-0.66	0.83
σ_a	0.01	0.04	0.0231	0.0166	0.0313	0.033	0.028	0.038
ρ_a	0.3	0.9	0.8	0.73	0.9	0.87	0.79	0.93
ϕ	2	8	5.13	3.56	6.54	4.6	3	6.5
σ_ν	0.2	0.55	0.44	0.36	0.54	0.51	0.37	0.8
ρ_ν	0.5	0.99	0.86	0.815	0.917	0.86	0.74	0.93
σ_μ	0.01	0.06	0.041	0.0315	0.0519	0.056	0.034	0.08
ρ_μ	0.5	0.96	0.88	0.79	0.96	0.91	0.83	0.97
ψ	2	5	3.3	2	4.56	2.8	1.3	4.6
			Measurement errors					
σ_y^{me}	0.01	$\sqrt{0.13}$	0.010	0.01	0.012	10^{-4}	10^{-4}	10^{-4}
σ_c^{me}	0.01	$\sqrt{0.19}$	0.012	0.01	0.014	10^{-4}	10^{-4}	0.0002
σ_i^{me}	0.05	$\sqrt{0.51}$	0.059	0.042	0.076	0.0012	0.0002	0.0032
σ_{tby}^{me}	0.05	$\sqrt{0.13}$	0.010	0.01	0.011	10^{-4}	10^{-4}	10^{-4}
Log-Lik.			614.1			600.5854		

Note: Model GPU refers to results of the financial frictions model of Garcia-Cicco et al. (2002). Model U(C,K) refers to results of the presented wealth-in-Utility model.

The volatility of the trade-balance-to-output ratio and its negative correlation with the consumption and investment growth are correctly predicted by the model. Characteristic moments of investment appear also better captured. As regards the autocorrelation function, the estimated coefficients are quite high, albeit acceptable if one takes into consideration confidence intervalls (of approximately two standard errors). Yet, the previous simulation exercise was predicting exactly the opposite, i.e., the introduction of a preference for wealth implies lower autocorrelation coefficients of the trade balance to output ratio. In fact, the reason why it is not the case here, is because the calibrated steady-state level of external debt has been increased to 0.14 compared to the calibrated value of 0.007 in the GPU framework used previously for the simulations. It has indeed been calibrated to target a steady-state debt-to-ouput ratio of 45% as indicated by world bank data.

TABLE 1.3: Second moments of Data and Models

Moments	Data	Stderr	GPU	Model U(C,K) Estimated (a)	Model U(C,K) Estimated (b)	Model U(C,S)
$\sigma(g^Y)$	5.3	(0.4)	6.3	6.4	6.41	6.33
$\sigma(g^C)$	7.5	(0.6)	8.4	9.02	8.94	8.71
$\sigma(g^I)$	20.4	(1.8)	17.7	16.03	18.57	17.31
$\sigma(TBY)$	5.2	(0.6)	5.1	5.67	6.66	5.73
$\rho(g^Y, g^C)$	0.72	(0.07)	0.79	0.82	0.83	0.82
$\rho(g^Y, g^I)$	0.67	(0.09)	0.35	0.44	0.48	0.45
$\rho(g^Y, TBY)$	-0.04	(0.09)	-0.02	-0.19	-0.22	-0.22
$\rho(TBY, g^C)$	-0.27	(0.07)	-0.28	-0.37	-0.37	-0.39
$\rho(TBY, g^I)$	-0.19	(0.08)	-0.24	-0.18	-0.13	-0.17
$\rho(g^Y)$	0.11	(0.09)	0.04	-0.01	0.0011	0.01
$\rho(g^C)$	-0.01	(0.08)	-0.01	-0.057	-0.032	-0.04
$\rho(g^I)$	0.32	(0.1)	-0.09	-0.016	0.0145	-0.002
$\rho(TBY)$	0.58	(0.07)	0.53	0.664	0.759	0.68
$\rho_{t-2}(TBY)$	0.26	(0.098)	0.28	0.48	0.5928	0.48
$\rho_{t-3}(TBY)$	0.14	(0.099)	0.16	0.38	0.48	0.36
$\rho_{t-4}(TBY)$	0.08	(0.099)	0.09	0.32	0.4096	0.29

Note: 'Model GPU' refers to the financial frictions model of Garcia-Cicco et al. (2010). 'Model U(C,K) Estimated (a)' refers to the presented wealth-in-Utility model under the calibration presented in Table 1.1. 'Model U(C,K) Estimated (b)' refers to the presented wealth-in-utility model where $D*$, τ and ξ are estimated (rather than calibrated as in Table 1.1). Model U(C,S) refers to the wealth-in-utility model under an alternative utility function involving a direct preference for saving (presented in section 4 which addresses robustness checks).

When looking at the decomposition variance analysis exposed in table 1.4, the permanent productivity shock appears to explain around one half of output volatility. This result is drastically different from the one of GPU who find, under the absence of a utility wealth effect and an arguably low level of external debt, a fraction of output volatility explained by permanent shocks of only 7.4%. Concerning the volatility of investment and the trade-balance-to-output ratio, the model still confirms that productivity disturbances play a minor role in the explanation. The model predicts in turn a more important role of the time preference shock, despite a lower estimated size (as expected).

TABLE 1.4: Variance Decomposition Predicted by the Model U(C,K) of section 2.3.1

GPU Model

Shock	g_Y	g_C	g_I	TBY
Nonstationry Tech.	7.4	4.3	1.5	0.4
Stationary Tech.	84.2	51.3	15.9	1.3
Preference	5.5	39.1	20.2	19.3
Country premium	2.9	5.2	62.4	78.9

Model U(C,K) Estimated (a)

Shock	g_Y	g_C	g_I	TBY
Nonstationry Tech.	51.19	40.46	17.42	14.39
Stationary Tech.	42.5	22.75	7.23	2.93
Preference	5.29	30.89	32.61	41.51
Country premium	1.01	5.88	42.74	41.17

Model U(C,K) Estimated (b)

Shock	g_Y	g_C	g_I	TBY
Nonstationry Tech.	54.34	44.44	23.94	18.13
Stationary Tech.	38.89	19.96	7.03	3.46
Preference	5.67	29.76	32.11	47.24
Country premium	1.09	5.83	39.91	31.16

Model U(C,S)

Shock	g_Y	g_C	g_I	TBY
Nonstationry Tech.	62.32	46.43	20.72	14.87
Stationary Tech.	31.65	16.12	5.35	2.68
Preference	4.97	31.72	32.87	38.57
Country premium	1.05	5.73	41.04	43.87

Note: 'Model GPU' refers to the financial frictions model of Garcia-Cicco et al. (2010). 'Model U(C,K) Estimated (a)' refers to the presented wealth-in-Utility model under the calibration presented in table 1.1. 'Model U(C,K) Estimated (b)' refers to the presented wealth-in-utility model where $D*$, τ and ξ are estimated (rather than calibrated as in table 1.1). Model U(C,S) refers to the wealth-in-utility model under an alternative utility function (presented in section 4 which addresses robustness checks).

1.4 Robustness

1.4.1 Impacts on estimations of Garcia-Cicco et al.

It is worthwhile to analyse what exactly drives this drastic change in the prediction of the GPU model. Is it the presence of a utility wealth effect as suggested previously by the simulation exercise, or is it the calibration, and for instance of the external-debt, which influences the estimation results obtained in the previous section ?

To answer this question, I proceed in two different steps. First, I recall the GPU framework with its calibrated and estimated values and assume some relatively high value for τ, say for example 0.1. I perform an estimation of parameters under this assumption. I expect a relatively high estimated size of trend shocks according to the previous discussion, and if so, I then test different values of τ in a decreasing order to approximate the limit below which trend shocks become negligible. This should necessarily arise since the model of GPU is estimated under an implicit $\tau = 0$. Second, I replicate the same estimation exercise for the wealth-in-utility model calibrated previously (the one labelled 'Model U(C,K) Estimated (a)').

Figure 1.7 displays results of this exercise. Several points are worth underlying. First, extending the GPU model to incorporate a plausible utility-wealth effect (Panle I) tends to imply a higher size of the permanent productivity shock as expected, along with a decrease of the transitory productivity shock. However, it seems not to be a positive monotonic relation. The size of the shock increases sharply from $\tau = 0$ to $\tau = 0.025$ and then decreases from $\tau = 0.025$ to $\tau = 0.05$ before rising again. Second, it seems that increasing τ tends to lower the likelihood value, but variations remain unsignificant for $\tau \leq 0.1$.

As regards the wealth-in-utility model (Panel II), which differs essentially from the GPU framework through the calibration of D^*, the value of the likelihood rises as τ increases up to 0.5. Interestingly, the estimated size of trend shocks is relatively higher and appears less sensitive to the value of τ compared to the standard GPU case. In conclusion, the hypothesis of a utility-wealth effect can not be rejected, and as the level of the calibrated steady-state external debt increases, the contribution of the utility-wealth effect to changes in estimations of the size of productivity shocks becomes less important. Those results mean in consequence that the debate that opposes the GPU to the AG views in the literature, seems to rely on the true values of

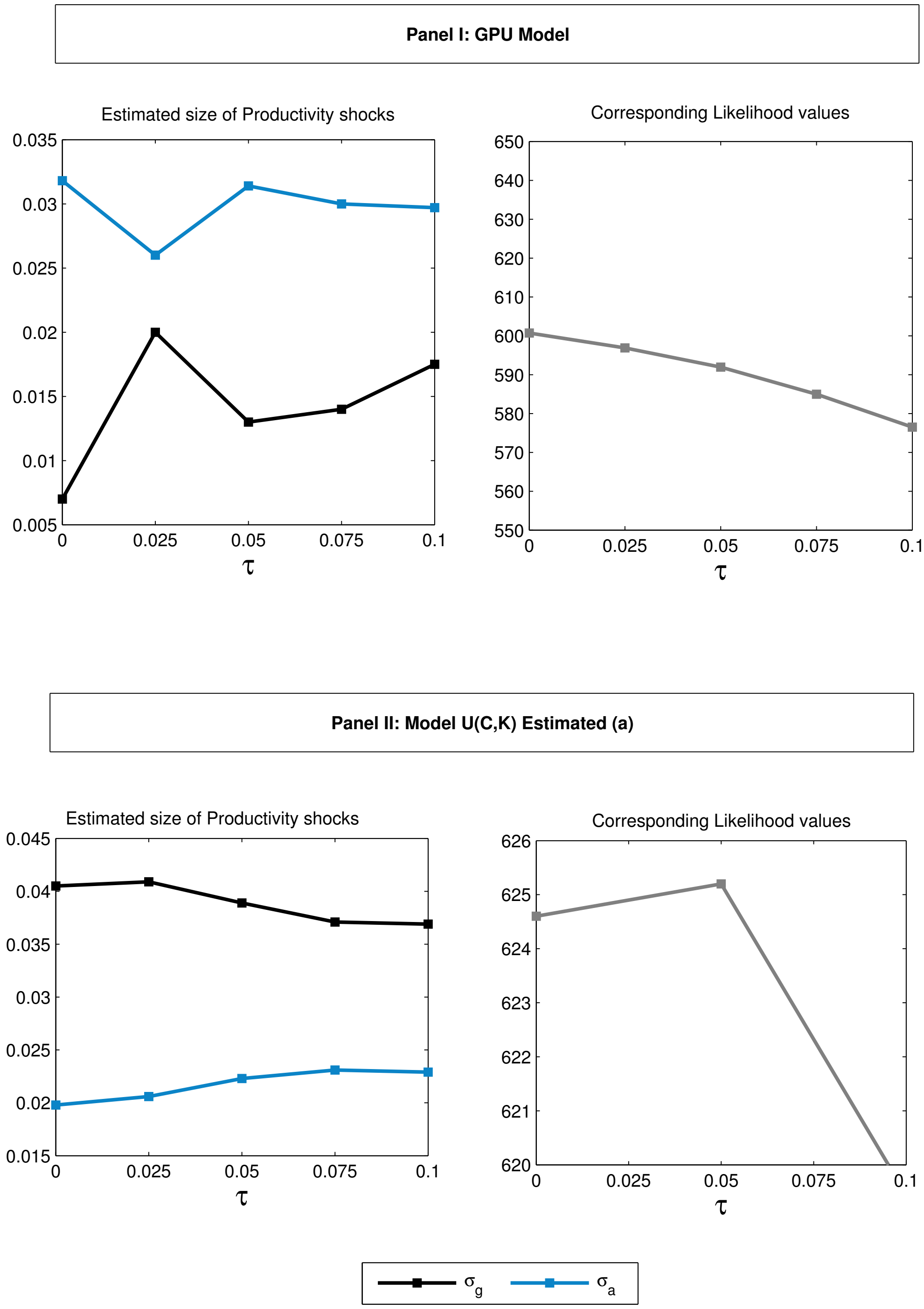

FIGURE 1.7: Productivity shocks as a function of the wealth preference parameter

D^* and τ. If D^* is low and calibrated to match the trade balance-to-output ratio as suggested by GPU, then a plausible small value of 0.025 for τ raises serious doubts about the minor role of trend shocks (Figure 1.7 indicates an estimated median of 2% for the size of the trend shock an dapproximately 2.5% for the temporary productivity shock). If D^* gets higher, the quality of fit tends to improve slightly (in view of the likelihood values) and the role of trend shocks tends to get more important in explaining business fluctuations in Argentina independently from the assumption of a utility-wealth effect.

1.4.2 Robustness of the wealth-in-utility model

In this section, I propose various types of robustness checks concerning predictions of the wealth-in-utility model. The first one consists in including D^*, τ, and ξ to the estimated set of parameters Ω. Results of the estimation procedure are displayed in Table 1.5 ('Model U(C,K) Estimated (b)') and in Figure 1.8 in appendix. The three parameters are well-identified in the data in view of well-shaped likelihood functions and posterior distributions peaking at values significantly different from zero. The posterior mean of D^* is close to the one that has been calibrated previously (with 0.155 versus 0.14). The estimated level of τ approaches the critical value of 0.025 identified previously in the robustness checks, and the estimated value of ξ is slightly higher than its previous calibrated value (0.03 vs 0.02). The likelihood value is increased to 624 and all remaining estimated parameters remain almost unchanged compared to the previous case where τ, D^* and ξ have been calibrated.

A further robustness check could eventually consist in testing an alternative utility functionnal form. Among the possibilities to formalize the desire to accumulate wealth for sociological or psychological reasons, is a Utility function that involves a direct preference for saving a part of income that will benefit children; examples in the joy-of-giving literature are Andreoni (1990), Dynan, Skinner and Zeldes (2002), or Khelifi (2016). The idea remains the same but the mathematical formulation and implications differ from the case of a direct preference for the stock of wealth studied so far. Here, we formalize precisely the fact that individuals obtain utility from setting money aside for children or specific gifts (examples could be a bequest, the purchase of a car, a flat, the payment of studies, etc.). We will refer to this framework as the model U(C,S). The aggregate utility function is expressed as:

$$E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \frac{\left[(1-\tau)C_t + \tau S_t - \theta.\omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma} \tag{1.7}$$

where τS_t measures the utility obtained from the part of income saved for children. We express this preference relatively to the one for consumption $(1-\tau)C_t$, since parental altruism signifies also self-sacrifice for children (and this is clearly plausible in emerging and poor countries).

TABLE 1.5: Posterior Distributions in other Model settings

	Posterior Statistics					
	Model U(C,K) Estimated (b)			U(C,S)		
Parameter	Median	5%	95%	Median	5%	95%
g	1.0049	1.00	1.009	1.006	1.0	1.012
σ_g	0.0389	0.0287	0.0493	0.0041	0.032	0.051
ρ_g	0.466	0.3041	0.6263	0.5	0.36	0.65
σ_a	0.0219	0.0134	0.0294	0.019	0.012	0.027
ρ_a	0.7813	0.668	0.899	0.79	0.66	0.98
ϕ	5.8475	4.3746	7.5329	6.33	5.17	7.75
σ_ν	0.4714	0.3946	0.549	0.47	0.37	0.6
ρ_ν	0.853	0.8	0.902	0.85	0.78	0.91
σ_μ	0.0394	0.0292	0.0508	0.059	0.047	0.07
ρ_μ	0.837	0.646	0.96	0.87	0.76	0.99
ψ	3.887	2.728	4.99	7.36	5.21	9.48
D^*	0.155	0.111	0.2			
τ	0.0272	0.01	0.0416			
ξ	0.03	0.0211	0.04			
Log-Lik.	623.81			618.06		

Note: Prior distributions and intervalls are the same as in Table 1.2. 'Model U(C,K) Estimated (b)' refers to the presented wealth-in-utility model where $D*$, τ and ξ are estimated

The calibration of the model is close to the one of the previous wealth-in-utility model exposed in table 1.1. The value of τ and the value of D^* are deduced as previously, giving $\tau = 0.2$ and $D^* = 0.09$. Results of the estimation are exposed in table 1.5. The likelihood value is once again higher than in the standard GPU framework. Despite a drastically different Utility function used to formalize the desire to accumulate wealth, all estimated parameters remain extremely close to those estimated previously. The significance of both productivity shocks is thus confirmed, playing therefore each a specific role in the explanation of business cycles of Argentina.

A final robustness check consists in considering that indviduals value precisely their stock of net weath given by $K_t - D^*$. It is indeed a plausible assumption in a context of a SOE model where the economy is given the possibility to contract external debt. The utility function can indeed be supposed as:

$$E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \frac{\left[(1-\tau)C_t + \tau(K_t - D_t) - \theta.\omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma} \tag{1.8}$$

The resolution of the household program changes. The first ordrer condition with respect to D_{t+1} becomes:

$$\lambda_t = \beta(1 + r_t)(1 + 1/g_t^{\gamma}) E_t \lambda_{t+1} \tag{1.9}$$

Following the same calibration set as the one presented in Table 1.1, the estimation provides results very close to those of the wealth-in-utility model of section 2.3. Detailed results are reported in appendix.

1.5 Conclusion

Considering that individuals save only to defer own consumption in the future on the basis of the (discounted) rate of return, is known to be a strong assumption in the standard neoclassical model. Guided by numerous contributions studying the wealth-preference concept and its implications, I attempt to investigate the role of this type of preference in the ongoing debate on business cycles of small open economies. I remind first that a high preference for capital accumulation is not necessarily a characteristic of rich countries, since it tends to generate a dynamics of macro variables close to the one observed in poor countries; i.e. the volatility of consumption relatively to the one of income increases with the degree of preference for wealth. I then show that the assumption of a preference for wealth can not be rejected, and that it might contribute to significant changes in estimations, in particluar of the size of permanent and transitory productivity shocks in the GPU model. Results show also that the calibrated level of steady-state external debt can affect drastically estimations of the size of productivity shocks. If the steady-state external debt is low and calibrated to match the trade balance-to-output ratio as suggested by Garcia-cicco et al (2010), then a relatively small degree of preference for wealth can modify their conclusion about the predominance of transitory shocks over permanent ones in the explanation of business cycles in Argentina (from 1900 to 2005). If the steady-state external debt gets higher, in order to match for example the observed debt-to-output ratio from 1970 to 2005, the quality of fit tends to improve and the role of trend shocks tends to get more important in explaining business fluctuations in Argentina, independently from the assumption of a utility-wealth effect.

In other words, the influential conclusion of Garcia-cicco et al. (2010) might actually not be sufficiently robust to reject the hypothesis of Aguiar and Gopinath (2007) that 'the cycle is the trend'. However, further studies remain necessary to dissociate the effects involved in the explanation of macro indicators and most importantly, to understand the true reasons why the volatility of consumption is relatively higher than the one of output in almost all poor countries. For instance, the time preference shock as supposed by GPU still play an important role in explaining the high volatility of consumpiton in our framework. The assumption of a utility-wealth effect has not changed this result as it could have been expected. The question is that if the preference shock is indeed the explanation, then why is the relative volatility greater in poor countries than in rich countries? It sounds indeed contradicting with the fact that in poor countries, a larger part of consumption is incompressible and composed of first necessity goods, and the lower incomes should imply limited possibilities to save.

1.6 References

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1.7 Appendix: Resolution of the model U(C,K)

1.7.1 Equilibrium conditions in agregate form

In solving the optimization program, households control four variables at time t, C_t, $Dt+1$, h_t, and $Kt+1$:

$$L = E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \left[\frac{\left[C_t + \tau K_t - \theta.\omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma} \right] \tag{1.10}$$

$$+\lambda_t X_{t-1}^{-\gamma} \left[q_t D_{t+1} - D_t + Y_t - C_t - K_{t+1} + (1-\delta)K_t - \xi K_t - \frac{\phi}{2}\left(\frac{Kt+1}{K_t} - g\right)^2 K_t \right] \tag{1.11}$$

with:

$$Y_t = a_t K_t^{\alpha} (X_t h_t)^{1-\alpha} \tag{1.12}$$

i) First-order condition with respect to respect to C_t:

$$\left[\frac{C_t}{X_{t-1}} + \tau_i . \frac{K_t}{X_{t-1}} - \theta.\omega^{-1} h_t^{\omega} \right]^{-\gamma} = \lambda_t \tag{1.13}$$

ii) First-order condition with respect to respect to h_t:

$$\left[\frac{C_t}{X_{t-1}} + \tau_i . \frac{K_t}{X_{t-1}} - \theta.\omega^{-1} h_t^{\omega} \right]^{-\gamma} \theta X_{t-1} h_t^{\omega-1} = \lambda_t (1-\alpha) a_t \left(\frac{K_t}{X_{t-1} h_t} \right)^{\alpha} X_{t-1}^{\alpha} X_t^{1-\alpha} \tag{1.14}$$

which can be rewriten as:

$$\left[\frac{C_t}{X_{t-1}} + \tau_i.\frac{K_t}{X_{t-1}} - \theta.\omega^{-1}h_t^{\omega}\right]^{-\gamma} \theta h_t^{\omega-1} = \lambda_t(1-\alpha)a_t\left(\frac{K_t}{X_{t-1}h_t}\right)^{\alpha}\left(\frac{X_t}{X_{t-1}}\right)^{1-\alpha} \quad (1.15)$$

This simplifies to:

$$\theta h_t^{\omega-1} = (1-\alpha)a_t\left(\frac{K_t}{X_{t-1}h_t}\right)^{\alpha} g_t^{1-\alpha} \quad (1.16)$$

iii) First-order condition with respect to respect to D_{t+1}:

$$\lambda_t = \frac{\beta(1+r_t)}{g_t^{\gamma}} E_t\lambda_{t+1} \quad (1.17)$$

iv) First-order condition with respect to Kt+1:

$$\lambda_t X_{t-1}^{-\gamma}\left[1+\phi(\frac{K_{t+1}}{K_t}-g)\right] = \frac{\beta}{g_t^{\gamma}}E_t\lambda_{t+1}X_t^{-\gamma}[\tau+1-\delta-\xi + \alpha a_{t+1}(\frac{h_{t+1}X_{t+1}}{K_{t+1}})^{1-\alpha} + \phi(\frac{K_{t+2}}{K_{t+1}}-g)\frac{K_{t+2}}{K_{t+1}} - \frac{\phi}{2}(\frac{K_{t+2}}{K_{t+1}}-g)^2] \quad (1.18)$$

1.7.2 Equilibrium conditions in stationary form

Define $y_t = Y_t/X_{t-1}$, $c_t = C_t/X_{t-1}$, $d_t = D/X_{t-1}$, and $k_t = K_t/X_{t-1}$. Then, a stationary competitive equilibrium is given by a set of solution to the following equations:

i) First-order condition with respect to respect to C_t:

$$\left[c_t + \tau_i.k_t - \theta.\omega^{-1}h_t^{\omega}\right]^{-\gamma} = \lambda_t \quad (1.19)$$

ii) First-order condition with respect to respect to h_t:

$$\theta.h_t^{\omega-1} = (1-\alpha)a_t \left(\frac{k_t}{h_t}\right)^{\alpha} g_t^{1-\alpha} \tag{1.20}$$

iii) First-order condition with respect to respect to D_{t+1}:

$$\lambda_t = \frac{\beta}{g_t^{\gamma}}(1 + r^* + \psi(e^{\tilde{D}_{t+1}-D} - 1))E_t\lambda_{t+1} \tag{1.21}$$

iv) First-order condition with respect to Kt+1:

$$\begin{aligned}\lambda_t \left[1 + \phi(\frac{k_{t+1}}{k_t}g_t - g)\right] &= \frac{\beta}{g_t^{\gamma}}E_t\lambda_{t+1}[\tau + 1 - \delta - \xi \\ &+ \alpha a_{t+1}(\frac{h_{t+1}g_{t+1}}{k_{t+1}})^{1-\alpha} + \phi(\frac{k_{t+2}}{k_{t+1}}g_{t+1} - g)\frac{k_{t+2}}{k_{t+1}}g_{t+1} - \frac{\phi}{2}(\frac{k_{t+2}}{k_{t+1}}g_{t+1} - g)^2]\end{aligned} \tag{1.22}$$

v) The budget constraint in stationnary for:

$$\frac{d_t + 1}{1 + r*}g_t = d_t - y_t + c_t + i_t + \xi k_t + \frac{\phi}{2}(\frac{k_{t+1}}{k_t}g_t - g)^2 \tag{1.23}$$

knowing that the production function in stationnary form is given by:

$$y_t = a_t k_t^{\alpha}(g_t h_t)^{(1-\alpha)} \tag{1.24}$$

and the dynamic equation of capital accumulation by:

$$k_{t+1}g_t = (1-\delta)k_t + i_t \tag{1.25}$$

1.7.3 Steady-State

Assuming $k_{t+1} - k_{t+1} = 0$, we obtain from equation (iv):

$$\frac{k}{gh} = \left[\frac{\frac{g^{\gamma}}{\beta} - 1 + \delta + \xi - \tau}{\alpha}\right]^{(1/(\alpha-1))} \tag{1.26}$$

From equation (ii) we have:

$$h = \left[(1-\alpha) * g\left(\frac{k}{gh}\right)^{\alpha} / \theta\right]^{(1/(\omega-1))} \tag{1.27}$$

We can then deduce easily steady-state values for the remainnig variables:

$$y = k^{\alpha}(gh)^{(1-\alpha)} \tag{1.28}$$

1.8 Appendix: Resolution of the model U(C,S)

In solving the optimization program, households control at time t C_t, I_t, $Dt+1$, h_t, and $Kt+1$:

$$L = E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \frac{\left[(1-\tau)C_t + \tau I_t - \theta\omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma} \tag{1.29}$$

$$+\lambda_{1t} X_{t-1}^{-\gamma} \left[q_t D_{t+1} - D_t + Y_t - C_t - I_t + \lambda_2((1-\delta)K_t + I_t - K_{t+1}) - \xi K_t - \frac{\phi}{2}\left(\frac{Kt+1}{K_t} - g\right)^2 K_t \right] \tag{1.30}$$

where λ_{1t} and λ_2 denote two lagrangian multipliers. First order conditions imply for instance that

$$\lambda_2 = \frac{2\tau - 1}{\tau}.$$

The variable λ_2 can also be viewed as the Tobin's price of capital (see Schmitt-Grohe and Uribe, 2015 p.93). The remaining of the resolution is similar to the previous section.

1.9 Appendix: Model U(C,K) with τ, D^*, and ξ estimated

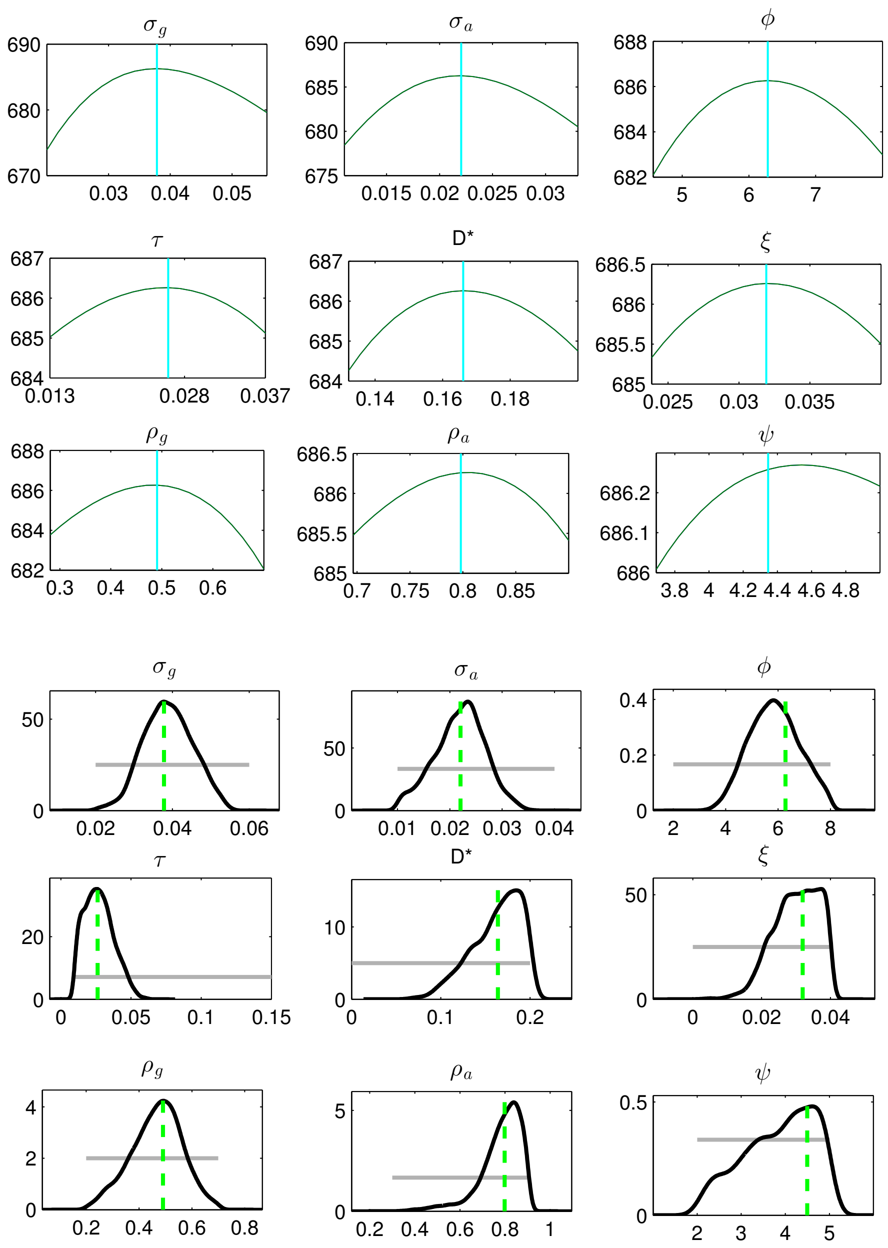

FIGURE 1.8: Approximated likelihood functions and Posterior distributions

1.10 Appendix: Resolution of the model U(C,K-D)

In an SOE model where the economy is given the possibility to contract external debt, the assumption of wealth-in-utility could be formulated in net terms; i.e., individuals can be supposed to value $K_t - D_t$. In that case, the agregate utility to maximize would be given by:

$$E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \frac{\left[(1-\tau)C_t + \tau(K_t - D_t) - \theta.\omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma} \tag{1.31}$$

The resolution of the household program changes. The first ordrer condition with respect to D_{t+1} becomes:

$$\lambda_t = \beta(1+r_t)(1+1/g_t^{\gamma})E_t\lambda_{t+1} \tag{1.32}$$

Calibrated parameters are presented in Table 1.1. Results of the estimation procedure are displayed in the Figure 1.9. Parameter estimates are presented in Table 1.6 (in comparison with the initial wealth-in-utility model of section 2.3). The second moments are globally well approximated. In particular, moments associated to the Investment variable are better captured but to the detriment of the autocorrelation function of the trade-balance-to-output ratio.

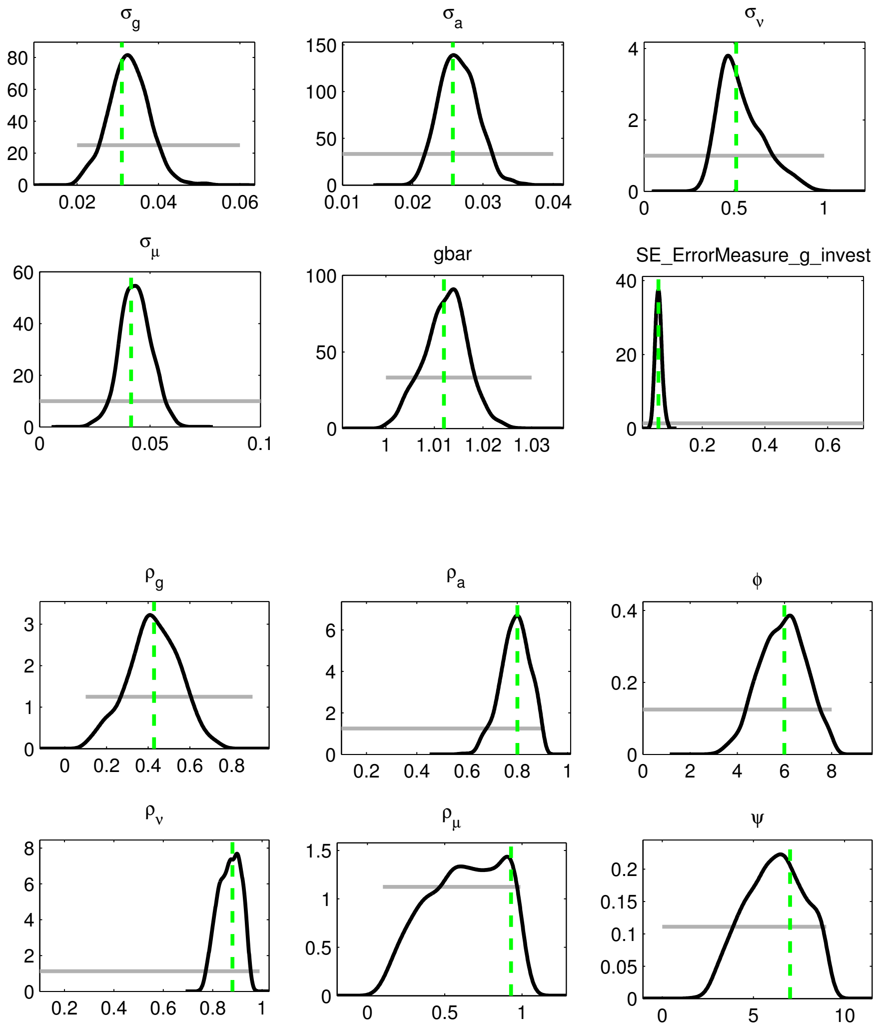

FIGURE 1.9: Posterior distributions

TABLE 1.6: Prior and Posterior Distributions of the U(C,K-D) Model

Parameter	Prior distribution Min	Max	Posterior distribution: Model U(C,K) Estimated (a) Median	5%	95%	Model U(C,K-D) Median	5%	95%
g	1	1.03	1.018	1.01	1.026	1.012	1.003	1.019
σ_g	0.02	0.06	0.038	0.0255	0.049	0.033	0.022	0.041
ρ_g	0.2	0.7	0.48	0.34	0.62	0.42	0.20	0.61
σ_a	0.01	0.04	0.0231	0.0166	0.0313	0.0265	0.022	0.031
ρ_a	0.3	0.9	0.8	0.73	0.9	0.79	0.71	0.90
ϕ	2	8	5.13	3.56	6.54	5.91	4.35	7.44
σ_v	0.2	0.55	0.44	0.36	0.54	0.54	0.35	0.74
ρ_v	0.5	0.99	0.86	0.815	0.917	0.87	0.797	0.93
σ_μ	0.01	0.06	0.041	0.0315	0.0519	0.043	0.032	0.055
ρ_μ	0.5	0.96	0.88	0.79	0.96	0.62	0.29	0.99
ψ	2	5	3.3	2	4.56	6.16	3.99	8.98
Log-Lik.			614.1			613.27		

Note: Model Model U(C,K-D) refers to results of the financial frictions model of Garcia-Cicco et al. (2002). Model U(C,K) refers to results of the initial wealth-in-Utility model presented in section 2.3.

TABLE 1.7: Second moments of the U(C,K-D) Model

Moments	Data	Stderr	GPU	Model U(C,K) Estimated (a)	Model U(C,K) Estimated (b)	Model U(C,S)	Model U(C,K-D)
$\sigma(g^Y)$	5.3	(0.4)	6.3	6.4	6.41	6.33	6.43
$\sigma(g^C)$	7.5	(0.6)	8.4	9.02	8.94	8.71	9.1
$\sigma(g^I)$	20.4	(1.8)	17.7	16.03	18.57	17.31	16.92
$\sigma(TBY)$	5.2	(0.6)	5.1	5.67	6.66	5.73	7.45
$\rho(g^Y, g^C)$	0.72	(0.07)	0.79	0.82	0.83	0.82	0.84
$\rho(g^Y, g^I)$	0.67	(0.09)	0.35	0.44	0.48	0.45	0.47
$\rho(g^Y, TBY)$	-0.04	(0.09)	-0.02	-0.19	-0.22	-0.22	-0.20
$\rho(TBY, g^C)$	-0.27	(0.07)	-0.28	-0.37	-0.37	-0.39	-0.31
$\rho(TBY, g^I)$	-0.19	(0.08)	-0.24	-0.18	-0.13	-0.17	-0.15
$\rho(g^Y)$	0.11	(0.09)	0.04	-0.01	0.0011	0.01	-0.019
$\rho(g^C)$	-0.01	(0.08)	-0.01	-0.057	-0.032	-0.04	-0.04
$\rho(g^I)$	0.32	(0.1)	-0.09	-0.016	0.0145	-0.002	0.025
$\rho(TBY)$	0.58	(0.07)	0.53	0.664	0.759	0.68	0.80
$\rho_{t-2}(TBY)$	0.26	(0.098)	0.28	0.48	0.5928	0.48	0.67
$\rho_{t-3}(TBY)$	0.14	(0.099)	0.16	0.38	0.48	0.36	0.59
$\rho_{t-4}(TBY)$	0.08	(0.099)	0.09	0.32	0.4096	0.29	0.53

Note: 'Model GPU' refers to the financial frictions model of Garcia-Cicco et al. (2010). 'Model U(C,K) Estimated (a)' refers to the presented wealth-in-Utility model under the calibration presented in Table 1.1. 'Model U(C,K) Estimated (b)' refers to the presented wealth-in-utility model where $D*$, τ and ξ are estimated (rather than calibrated as in table 1.1). Model U(C,S) refers to the wealth-in-utility model under an alternative utility function involving a direct preference for thriftiness (saving). Model U(C,K-D) refers to the case where individuals value net wealth.

2 World Prices and Business Cycles of a Small Open Input-Output Economy

The role of terms-of-trade shocks in driving economic fluctuations is revisited through a multisector small open economy (SOE) model, where the various types of goods can all be consumed and employed as inputs. Under this assumption, we show that contrary to conventional wisdom, terms-of-trade shocks may not necessarily trigger an economic boom for the exporting country, if its export goods are intensively employed or consumed domestically. We calibrate and estimate the proposed model using data from 15 emerging countries and find that it performs better than the standard model to explain the different impacts of terms-of-trade shocks across countries documented by Schmitt-Grohe and Uribe (2018).

2.1 Introduction

Developping economies are known to exhibit high macroeconomic volatility. Seminal papers such as Mendoza, 1991 and Kose, 2002 have led to conventional wisdom suggesting that terms-of-trade shocks explain a large fraction of economic fluctuations in emerging countries. In a recent paper, Schmitt-Grohé and Uribe, 2018 challenge this prediction. They estimate a country-specific structural vector autoregression (SVAR) model based on 38 countries and show that the share of variance of macroeconomic indicators explained by terms-of-trade shocks represents approximately 10% on average, and not 30% as is commonly thought. They also perform a rigorous comparative analysis with a theoretical business cycle model, and find that once variables are measured in the same units as in the data, theoretical and empirical predictions converge on average. However, at the country-by-country level, theoretical results tend to over-estimate impulse responses of macroeconomic aggregates. They conclude therefore that it is necessary to understand origins of this disconnect problem, and discuss some potential avenues.

This disconnect could be partly driven by the fact that a single world price (terms of trade) may fail to capture the transmission mechanism of world shocks as advocated by Fernández, Schmitt-Grohé, and Uribe, 2017. The authors show that multiple world prices (of commodities) constitute a channel through which world shocks propagate better. Their results indicate that commodity price shocks explain a large fraction of business cycle fluctuations. In this case, an improvement of the empirical model pushes the empirical results closer to the theoretical predictions. Schmitt-Grohé and Uribe, 2018 argue that another way to resolve this disconnect could involve modifying the theoretical SOE model to allow for government policy to isolate fluctuations in terms of trade, which would attenuate their role.

I suggest in this paper a further proposition that consists of generalizing the theoretical SOE model used by Schmitt-Grohé and Uribe, 2018, in a way to incorporate explicitely the input-ouput structure of an economy so as to calibrate it accurately for each country. The structure of the standard SOE model they use and its calibration are indeed such that the input-output structure implicitely induced is the same for each country, with a domestic absorption of the export good representing only 5% of total output versus a median of 29% indicated by real data. In consequence, following a price increase of the export good on world markets (a terms-of-trade shock of 10 % for example), it is normal that the standard model tends to over-estimate the economic expansion generated for the exporting country (2% of growth on impact for each country), given it under-evaluates the negative effects related to its domestic use in terms of consumption and production. Improving the standard model as proposed allows to calibrate accurately the structure of the global demand for each country, and hence, to better account for the dampening effects of the increase in production and consumption prices following a terms-of-trade shock. Indeed, unless the degree of substitution between goods is relatively high in the domestic economy, a price increase of the export good on world markets discourages also production efforts through higher costs and lower real payoffs.

The alternative structure proposed to extend the standard SOE model is close those of existing input-output models, like for example Jones, 2011 or Johnson, 2014. The incoporation of an explicit input-output structure to the SOE model is in fact technically easier when assuming production functions that include intermediate goods in addition to capital and labor. This makes the structure different from the (round about) production system of the standard version of the model where capital and labor produce intermediate goods first, and where final goods are obtained in a second step by transforming different types of intermediate goods. Such a structure implies indeed a complicated calibration and constrained endogenous prices. In the proposed framework, any good can be used as an intermediate or capital good to reproduce itself, and can eventually be consumed. The structure of the model replicates exactly the one of input-output national accounts data, and it is the calibration which indicates whether a sector good can be viewed as essentially an intermediate or fixed capital input, or a final consumption good. The price of the import, export and non-tradable good are left exogenous and estimated using real data, for instance terms of trade, output, consumption, investment and the trade balance.

Before evaluating the contribution of the proposed theoretical model, I start with a discussion of empirical facts regarding the domestic use of export goods, and an SVAR analysis of the role of terms-of-trade shocks based on 15 emerging countries. I then follow the same comparision methodology as Schmitt-Grohé and Uribe, 2018 and find that the theoretical results of the proposed model (we will refer to as the SOE-IO model) confirm on average the moderate effect of terms-of-trade shocks of approximately 10% obtain with the SVAR model. That is, external shocks on export prices do not explain a large fraction of output volatility. In some cases, the dampening effects related to the global demand can also totally offset the positive effects of the supply side, so that the overall impact on output can even be nil, if not negative.

Using the estimated SOE-IO model, I also propose to analyse quantitatively the effects of different kinds of input-output structures within a domestic economy and to make a comparative analysis across countries. I conclude from this exercise that it is important to account for the right country-specific economic structure to understand the propagation of shocks on world prices to the domestic country and their impact on the dynamics of macroeconomic aggregates.

The remainder of this paper is organized as follows. Section 2 presents empirical facts regarding country-specific input-output structures and recalls the results of the SVAR model of Schmitt-Grohé and Uribe, 2018 about the role of terms-of-trade shocks in economic fluctuations. Section 3 develops a theoretical three-sector SOE model based on the structure of input-output data tables. Section 4 describes the calibration and estimation strategy. Section 5 analyzes the results in comparison with the empirical SVAR model. Section 6 investigates the role of the input-output structure regarding responses of macroeconomic aggregates to terms-of-trade shocks. Section 7 presents a sensitivity analysis of results with respect to different degrees of elasticity of substitution between goods., and section 8 concludes.

2.2 Empirical facts

2.2.1 Domestic use of export goods

The input-output structure of an economy matters for the impacts of terms-of-trade shocks. For example, a commodity exporter should produce more if the international price of that commodity rises. However, if the exported good is intensively employed in the domestic country with limited scope for substitution by other products, the price increase of that good translates into a higher general production and consumption price index (PPI and CPI, respectively), which may consequently dampen or eventually offset the growth cycle. Hence, in studying the role of terms-of-trade shocks, it is useful to first highlight, through empirical data, the heterogeneity across countries in terms of input-output structure, and precisely in terms of domestic use of export goods. It is also interesting to examine the effects of variations of export prices on production and consumption price indexes.

In this paper, I consider 15 countries of the 38 studied in Schmitt-Grohé and Uribe, 2018 for which the appropriate input-output data required to calibrate the theoretical model in section 3.4 are available; data come from from the World Input Output Database (Winput-outputD) and the OECD Input-Output Tables. Those countries are Argentina, Brazil, Colombia, Costa Rica, India, Indonesia, Malaysia, Mexico, Morocco, Peru, Philippines, South Africa, South Korea, Thailand, and Turkey. The first task is to define how to classify all sectors of each country within one of our three categories: the import, export and nontradable sectors. To do so, I set up a simple rule based on the degree of openness formalized by $\rho_j = \frac{M_j+X_j}{P_jQ_j}$, where M_j refers to imports and X_j to exports. Below a certain low degree $\rho*$, a sector is classified into the nontradable good sector, and above this limit, the sign of net exports is what determines whether the good is importable or exportable. Using input-output data from 2000, I determine the degree $\rho*$ that allows us to obtain the same size of the nontradable good sector as Schmitt-Grohé and Uribe, 2018 for each country, that is 50% of GDP. Nonetheless, I suggest an upper limit for this degree $\rho*_{max} = 20\%$, above which it becomes relatively implausible to define a sector as a nontradable one.

Table 2.1 presents the proportions of export goods used by each country as total intermediate consumption, total investment and total consumption. The use of export goods as intermediate consumption is detailed by sectors M, X, and N, referring to the import, export and nontradable good sectors, respectively. The total share is computed as the ratio of export goods absorbed domestically versus total output. We notice that for 8 countries out of 15, the use and consumption of export goods represents more than 29% of their total production. The highest shares are 40% for Malaysia and 36% for Thailand. In both countries, a large portion of export goods consists of products of mass consumption, for instance food, fuel, hotels and restaurants, nonmetallic materials and plastics, textiles and wood. The lowest share appears to be 11% for the Philippines. The country hardly consumes any export goods,

TABLE 2.1: Domestic Use of Export goods (%) and Price Index correlations

	Sectors						Prices Correlations	
Country	M	X	N	I	C	Global	$\rho(\Delta P^Y, \Delta P_x)$	$\rho(\Delta P^C, \Delta P_x)$
Argentina	33	55	25	10	25	29	0.082	-0.013
Brazil	20	45	21	18	19	22	0.017	0.071
Colombia	33	57	18	11	32	32	0.38	0.36
Costa Rica	10	39	32	68	24	29	NA	0.49
India	28	42	28	19	34	32	0.25	0.402
Indonesia	29	41	30	4	28	21	0.46	0.24
South Korea	22	62	27	30	19	32	0.65	0.76
Malaysia	22	66	40	23	35	40	0.012	0.55
Mexico	28	49	25	28	21	21	-0.12	0.33
Morocco	10	42	20	2	30	24	-0.19	0.37
Peru	12	43	19	1	20	20	-0.011	0.28
Philippines	4	43	10	14	3	11	0.31	0.59
South Africa	39	54	30	21	31	36	0.19	0.5
Thailand	31	50	39	26	33	36	0.73	0.75
Turkey	26	55	22	9	31	27	0.10	0.63
Median	26	49	25	18	28	29	0.14	0.40

Note: The table displays the shares of export goods in total intermediate goods used by each sector (M,X,N), the shares of export goods in total investment and consumption and a global share calculated with respect to total output. Data on shares of export goods are obtained by aggregating Winput-outputD and OECD Input-Output Data from 2000 by sector. Data on export good prices, PPI and CPI are obtained from Penn World Tables and Trading Economics.

which primarily consist of textile products, leather and footwear, wood products, computer and electronic equipment, manufacturing machinery, R&D and business activities.

In the last two columns, I represent the correlation of coefficients of growth rates of export good prices and growth rates of PPI and CPI of each country. In almost all countries (for which data are available), I notice a significant positive correlation between variations in export good prices and variations in the PPI and CPI (medians are 14.4% and 40.2%, respectively). Additionally, as expected, countries that use intensively export goods as production factors tend to exhibit strong correlations between production price index and export good prices (for example, Thailand, Colombia, South Korea and India), and countries that employ small fractions of export goods tend to exhibit low or even negative correlation coefficients (Turkey, Peru, Morocco, Argentina, and Brazil). On the final demand side, almost all countries consume a significant share of export goods (the median value is 28%), which is in accordance with high correlations of export good and consumption price index variations.

2.2.2 Empirical analysis of terms of trade shocks

This paper is an attempt to resolve the problem of the disconnect between theoretical and empirical predictions of Schmitt-Grohé and Uribe, 2018 concerning the effects of terms-of-trade shocks across countries. Given that my contribution consists in improving the theoretical model, I recall the results of their empirical SVAR model to make the same comparisons. The terms-of-trade effect is estimated country by country based on annual data (from 1980 to 2011) provided by the WDI database. We recall for instance the specification they present in section 3 of their paper, which includes the U.S. interest spread, the terms-of-trade variable, the U.S. dollar real exchange rate, gross domestic product (GDP), the gross fixed capital formation (investment), consumption, and the trade balance to output ratio. We concentrate on the 15 countries specified previously for which detailed input-output data is available (out of 38 in the benchmark study of Schmitt-Grohé and Uribe, 2018).

The terms-of-trade variable is defined as the ratio of the export to the import price index, denoted respectively P_{xt} and P_{mt}:

$$tot_t = \frac{P_{xt}}{P_{mt}}.$$

The real exchange rate included in the SVAR model is defined as:

$$RER_t = \epsilon_t \frac{P_t^{US}}{P_t},$$

where ϵ_t denotes the dollar price in domestic currency, P_t^{US} represents the

U.S. consumption price index, and P_t is the domestic consumption price index.

All variables are expressed in log deviations from a quadratic trend (the results are shown by SGU to be robust to HP filtering and first differencing). We note that the trade balance is divided by this estimated quadratic trend. The SVAR model is given by:

$$A_0 x_t = A_1 x_{t-1} + \mu_t, \tag{2.1}$$

where x_t denotes the vector of variables:

$$x_t \equiv \begin{bmatrix} \widehat{tot}_t \\ \widehat{s}_t \\ \widehat{tb}_t \\ \widehat{y}_t \\ \widehat{c}_t \\ \widehat{i}_t \\ \widehat{RER}_t \end{bmatrix}.$$

We let $\widehat{tot}_t$, $\widehat{s}_t$, $\widehat{tb}_t$, $\widehat{y}_t$, $\widehat{c}_t$, $\widehat{i}_t$, and $\widehat{RER}_t$ respectively denote log deviations of the terms of trade, the interest spread, the trade balance ratio, real output per capita, real private consumption per capita, real gross investment per capita, and the real exchange rate from their respective quadratic trends. The objects A_0 and A_1 are 7-by-7 matrices, and A_0 is assumed to be lower triangular, which implies that all variables do not affect the terms of trade contemporaneously. In line with the theoretical specification argued by Schmitt-Grohé and Uribe, 2018, I impose the restriction that all elements of the first two rows of A_1 be zero, except the first and second. The variable μ_t is a 7-by-1 vector of random variables with mean zero and variance-covariance matrix Σ. The reduced form of the model is obtained by premultiplying the system by A_0^{-1}:

$$x_t = Ax_{t-1} + \Pi\epsilon_t, \tag{2.2}$$

where $A \equiv A_0^{-1}A_1$, $\Pi \equiv A_0^{-1}\Sigma^{1/2}$, and $\epsilon_t \equiv \Sigma^{-1/2}\mu_t$. By construction, ϵ_t is a random vector with mean zero and identity variance-covariance matrix. The resulting system is supposed to be such that the first two equations take the form:

$$\begin{bmatrix} \widehat{tot}_t \\ \widehat{s}_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \widehat{tot}_{t-1} \\ \widehat{s}_{t-1} \end{bmatrix} + \begin{bmatrix} \pi_{11} & 0 \\ \pi_{21} & \pi_{22} \end{bmatrix} \begin{bmatrix} \epsilon_t^{tot} \\ \epsilon_t^{s} \end{bmatrix} \tag{2.3}$$

The innovations to the terms-of-trade and interest spread equations ϵ_t^{tot} and ϵ_t^s relate to the interpretation of the terms-of-trade shock and the interest spread shock, respectively. The system assumes that the terms-of-trade shock affects the interest spread contemporaneously, whereas spread shocks impact the terms of trade with one time delay.[1] The reduced form of the model is then estimated country by country by OLS (detailed results are presented in the Appendix). We find that the cross-country median of the estimated autocorrelation coefficient a_{11} is close to that of the entire sample of countries in Schmitt-Grohé and Uribe, 2018, with a value of 0.56 (versus 0.52), which confirms that terms-of-trade shocks vanish relatively quickly. The median standard deviation of 0.078 is also comparable (versus 0.08).

Figure 2.1 presents the median impulse response functions of the macroeconomic variables included in the SVAR model following a terms-of-trade shock of 10% (a value close to the median standard deviation of 0.08). As in the case of the entire sample of 38 countries, the trade balance increases by 0.5% GDP on impact. In other words, the results of our sample confirm

[1] In their paper, Schmitt-Grohé and Uribe, 2018 also consider the possible alternative assumption that interest spread shocks affect terms of trade contemporaneously. They show that the results and conclusions are robust to the choice of specification.

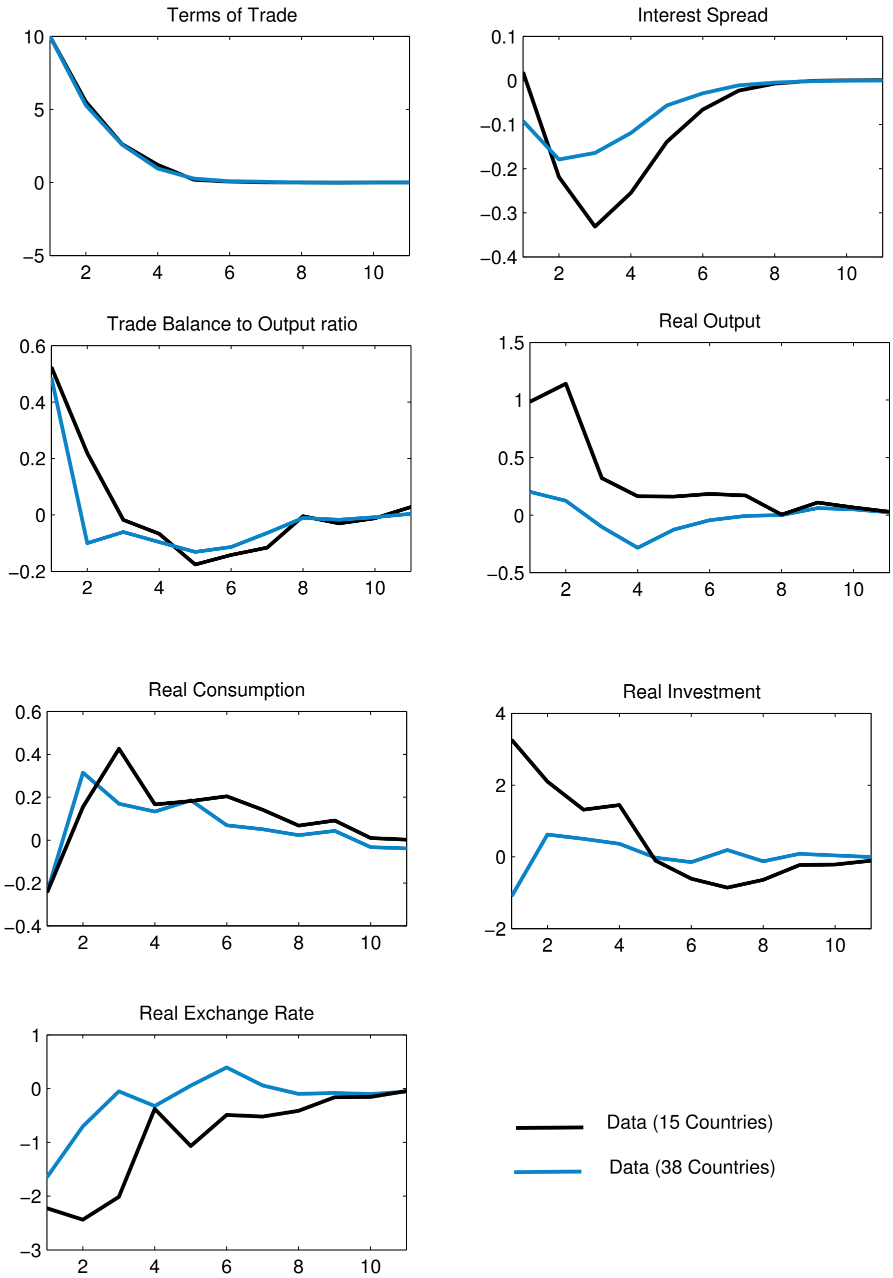

FIGURE 2.1: SVAR Impulse response functions following a 10% terms-of-trade shock

Note: Impulse responses are represented as point-by-point medians across countries. The country-specific impulse responses are presented in appendix with 66% confidence intervals.

the Harberger-Laursen-Metzler (HLM) effect obtained not only by Schmitt-Grohé and Uribe, 2018 but also by Otto, 2003, who used a sample of 40 developing countries between 1960 and 1996.

The increase in terms-of-trade causes a response of real GDP growth on impact of 1%, which is higher than that obtained for the 38 countries in Schmitt-Grohé and Uribe, 2018, for instance, 0.36%. This median response remains sufficiently low to reject the idea that terms-of-trade shocks play important roles in the business fluctuations of emerging countries. Concerning other responses, our sample confirms that private consumption contracts on impact before expanding above its equilibrium path. It also confirms that investment reacts positively, or even contemporaneously in this case. The real exchange rate appreciates above 2% on impact (versus 1.6% when considering the 38 countries) and appears to be slightly more persistent.

TABLE 2.2: Share of variances explained by terms-of-trade shocks

Country	tot	s	tb	y	c	i	RER
Argentina	97	5	27	13	12	9	29
Brazil	90	20	51	16	5	31	48
Colombia	98	1	8	19	5	16	14
Costa Rica	88	14	17	2	2	2	1
India	85	3	4	5	19	1	1
Indonesia	97	8	6	11	10	15	7
Korea	74	13	5	3	3	12	11
Malaysia	95	2	8	7	4	7	2
Mexico	85	3	9	10	9	7	26
Morocco	97	11	2	1	0	2	5
Peru	99	22	17	24	16	26	19
Philippines	99	10	23	20	22	7	36
South Africa	78	7	9	3	3	2	10
Thailand	73	19	26	24	25	23	32
Turkey	94	5	3	15	17	31	7
Median	94	8	9	11	9	9	11
Med Abs Dev.	5	5	6	8	6	7	9

As noted by Schmitt-Grohé and Uribe, 2018, responses differ substantially at the country level. For instance, the observed expansions in output and in the trade balance are not significant for 7 and 9 countries out of 15, respectively, in view of the 66% confidence interval including zero (please refer to the Appendix). This remark applies also to the other variables included in the SVAR model. As a conclusion, there is no evidence, through the lens of an empirical SVAR model, that terms-of-trade shocks constitute a major source of business cycles of emerging and resource-limited countries, as suggested by conventional wisdom. Another way to observe the moderate effect of terms-of-trade shocks is to examine the Table 3.1, which presents the share of variance of macroeconomic variables they explain. We indeed notice that terms-of-trade shocks explain approximately 10% of the volatility of macro variables on average. An interesting question is now to determine whether extending the theoretical model of Schmitt-Grohé and Uribe, 2018 to account for the country-specific input-output structure can help improve understanding of the different roles of terms-of-trade shocks across countries.

2.3 The theoretical model

2.3.1 The supply side

We consider three sectors indexed by $j = m, x, n$, with for instance m referring to an import good sector, x to an export good sector, and n to a non-tradable good sector. Each sector is composed of a large number of identical firms which employ labour and the goods produced as fixed and intermediate capital goods. This multi-sector model replicates the empirical structure of input-output tables. The technology in each sector exhibits constant returns to scale (CRS) and is defined as:

$$Q_{jt} = B_{jt}[K_j(X_t)^{\alpha}(A_t L_{jt})^{1-\alpha}]^{1-\theta} V_j(X_t)^{\theta} \tag{2.4}$$

where Q_{jt}, $V_j(X_t)$, $K_j(X_t)$, and L_{jt} denote respectively gross production, aggregate intermediate consumption, aggregate fixed capital, and labor employed by sector j at time t. The level of aggregate capital and intermediate consumption in each sector is expressed as a function of quantities of goods produced in the economy $X_t = (X_{mt}, X_{xt}, X_{nt})$. Producers chose $V_j(X_t)$,

$K_j(X_t)$, and L_{jt} so as to maximize:

$$\Pi_{jt} = p_{jt}Q_{jt} - u_{jt}K_j(X_t) - w_{jt}L_{jt} - P_t^{V_j}V_j(X_t)$$

where u_{jt} denotes the capital remuneration rate paid by sector j, $P_t^{V_j}$ is the price index of the intermediate good basket used by sector j, w_{jt} is the wage rate paid, and p_{jt} denotes the price of good j at time t. The first-order conditions are given by:

$$p_{jt}Q_{jK}[K_j(X_t), L_{jt}, V_j(X_t)] = u_{jt} \tag{2.5}$$

$$p_{jt}Q_{jL}[K_j(X_t), L_{jt}, V_j(X_t)] = w_{jt} \tag{2.6}$$

$$p_{jt}Q_{jV}[K_j(X_t), L_{jt}, V_j(X_t)] = P_t^{V_j} \tag{2.7}$$

2.3.2 Households

We recall the period utility function assumed by Schmitt-Grohé and Uribe, 2018. Households are supposed to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{[C(X_t) - G(L_{mt}, L_{xt}, L_{nt})]^{(1-\gamma)} - 1}{1-\gamma} \tag{2.8}$$

where $C(X_t)$ denotes aggregate consumption and where:

$$G(L_{mt}, L_{xt}, L_{nt}) = \frac{L_{mt}^{\tau_m}}{\tau_m} + \frac{L_{xt}^{\tau_x}}{\tau_x} + \frac{L_{nt}^{\tau_n}}{\tau_n}$$

with γ, τ_m, τ_x, and $\tau_n > 0$. This specification implies limited scope for labor mobility across sectors in case of different wages (as soon as τ_j is significantly greater than 1.) To simplify notations, let $C_t = C(X_t)$, $K_{jt} = K_j(X_t)$, and $V_{jt} = V_j(X_t)$. Let also real investment of sector j be defined as $I_{jt} = I_j(X_t)$. The sequential budget constraint faced by the household when maximizing this objective function is defined as:

$$P_t^C C_t + \sum_j \left(P_t^{I_j} I_{jt} + \frac{\phi_j}{2} \left(K_{jt+1} - K_{jt}\right)^2 \right) = \frac{\xi_t D_{t+1}}{1+r_t} - \xi_t D_t + \sum_j \left(u_{jt} K_{jt} + w_{jt} L_{jt}\right),$$

where P_t^C denotes the consumption price index, $P_t^{I_j}$ is the investment price index associated to the aggregate investment in fixed capital I_{jt} in sector j (expressed in real terms). The parameters ϕ_j refer to a capital adjustment cost in each sector. It is assumed indeed that final goods invested are not equally transformed into productive capital. The quantity $\xi_t D_t$ represents the amount of foreign debt due at time t in domestic currency, ξ_t represents the outstanding nominal exchange rate, and r_t denotes the debt interest rate from period t to $t+1$. I assume that the nominal exchange rate of the small open economy is affected by terms-of-trade shocks and follows an AR(1) process given by:

$$log(\xi_t) = \rho_\xi log(\xi_{t-1}) + \pi^\xi \epsilon_t^{tot} \tag{2.9}$$

where ϵ_t^{tot} refers to the terms-of-trade innovation and π^ξ, to the standard deviation of its impact. The laws of motion of capital are defined as[2]:

$$K_{jt+1} = (1-\delta)K_{jt} + I_{jt} \tag{2.10}$$

The resolution of the household's program consists in choosing C_t, L_{jt}, D_{t+1}, and K_{jt+1}, (j=m,x,n), so as to maximize the objective function (3.5) subject to the sequential budget constraint. The first-order conditions are (the detailed resolution is described in the Appendix):

$$\frac{U_C(C_t, L_{mt}, L_{xt}, L_{nt})}{P_t^C} = \lambda_t \tag{2.11}$$

[2]We suppose same functions for the aggregate measure of capital and investment. The assumption of an aggregate investment good can also be found in Fernández, González, and Rodriguez, 2018.

$$-U_{L_j}(C_t, L_{mt}, L_{xt}, L_{nt}) = \lambda_t w_{jt} \tag{2.12}$$

$$\lambda_t \xi_t = \beta(1+r_t)E_t\lambda_{t+1}\xi_{t+1} \tag{2.13}$$

$$\lambda_t[P_t^{I_j} + \phi_j(K_{jt+1} - K_{jt})] = \beta E_t \lambda_{t+1}[u_{jt+1} + (1-\delta)P_{t+1}^{I_j} + \phi_j(K_{jt+2} - K_{jt+1})] \tag{2.14}$$

2.3.3 Equilibrium of markets

Equilibrium of commodity markets implies :

$$\omega_{it}^C P_t^C C_t + \sum_j \omega_{it}^{I_j} P_t^{I_j} I_{jt} + \sum_j \omega_{it}^{V_j} P_t^{V_j} V_{jt} + NX_{it} = p_{it} Q_{it} \tag{2.15}$$

for $i, j = m, x, n$. The amount NX_{it} denotes net exports of good i at time t, and ω_{it}^C, $\omega_{it}^{I_j}$, and $\omega_{it}^{V_j}$ denote respecively optimal budget shares of final consumption, investment, and interemdiate consumption spent on good i. Letting $C(X_t)$, $I(X_t)$, and $V(X_t)$ be given by a CES Argminton aggregator, Armington, 1969), it is well known that price indexes and optimal shares maximizing $C(X_t)$, $I(X_t)$, and $V(X_t)$ have the following forms:

$$P_t^C = \left(\sum_i \zeta_i^{\sigma_C} p_{it}^{1-\sigma_C}\right)^{1/(1-\sigma_C)} \quad \omega_{it}^C = \zeta_i^{\sigma_C}\left(\frac{P_t^C}{p_{it}}\right)^{\sigma_C}, \tag{2.16}$$

$$P_t^{I_j} = \left(\sum_i \kappa_{ij}^{\sigma_{I_j}} p_{it}^{1-\sigma_{I_j}}\right)^{1/(1-\sigma_{I_j})} \quad \omega_{it}^{I_j} = \kappa_i^{\sigma_{I_j}}\left(\frac{P_t^{I_j}}{p_{it}}\right)^{\sigma_{I_j}}, \tag{2.17}$$

and

$$P_t^{V_j} = \left(\sum_i \nu_{ij}^{\sigma_{V_j}} p_{it}^{1-\sigma_{V_j}}\right)^{1/(1-\sigma_{V_j})} \quad \omega_{it}^{V_j} = \nu_{ij}^{\sigma_{V_j}}\left(\frac{P_t^{V_j}}{p_{it}}\right)^{\sigma_{V_j}}, \tag{2.18}$$

where ζ_i, κ_{ij}, and ν_{ij} define positive parameters of the corresponding CES aggregators, and where σ_C, σ_{I_j}, and σ_{V_j} correspond to degrees of elasticity of substitution between goods. Having defined equilibrium price indexes and budget shares, the resolution for the steady-state general equilibrium implies to determine the set of amounts NX_m^*, NX_x^*, and NX_n^* that satisfy equation (3.13) $\forall i, j = m, x, n$.. For the sake of simplicity, I let $\kappa_{ij} = \kappa_i$, $\omega_{it}^{I_j} = \omega_{it}^{I}$, and $P_t^{I_j} = P_t^I$, $\forall j = m, x, n$ (note indeed that information regarding gross fixed capital formation by sector is generally missing in input-output data.) As well, I propose $\sigma = \sigma_C = \sigma_{I_j} = \sigma_{V_j}$, $\forall j = m, x, n$ (to reduce the number of variables estimated next).

Summing equation 3.13 over each good i and combining the result with the budget constraint leads to:

$$\frac{\xi_t D_{t+1}}{1 + r_t} - \xi_t D_t = \sum_j \phi_j (K_{jt+1} - K_{jt}) - \sum_i NX_{it} \tag{2.19}$$

which means that indebtment finances net imports and capital adjustment costs. The trade balance is given by:

$$TB_t = -(\frac{\xi_t D_{t+1}}{1 + r_t} - \xi_t D_t) \tag{2.20}$$

The real exchange rate is expressed as:

$$RER_t = \frac{\xi_t P_t^{C*}}{P_t^C}, \tag{2.21}$$

where P_t^{C*} corresponds to the foreign consumption price index (for instance the U.S. consumption price index in the empirical counterpart) . The SVAR specification considers that terms-of-trade shocks influence the real-exchange rate, but not the reverse. Hence, assuming that changes in export good prices of the domestic country exert no real impacts on this foreign consumption price index, allows simplification of the measure of the theoretical real exchange rate dynamics (for instance, $RER_t = \frac{\xi_t}{P_t^C}$.)

Definition

Assuming an economy of J sectors that are indexed by j and that each produce a specific good $i \in J$, a competitive equilibrium is a set of $J \times 16 + 9$ processes K_{jt+1}, V_{jt}, L_{jt}, λ_t, Q_{jt}, I_{jt}, C_{it}, ω_{it}^C, ω_{it}^I, $\omega_{it}^{V_j}$, u_{jt}, w_{jt}, P_{xt}, P_{nt}, P_t^C, $P_t^{I_j}$, $P_t^{V_j}$, D_{t+1}, r_t, s_t, TB_t, RER_t and NX_{jt}, satisfying equations (3.1) to (3.11), given the initial conditions K_{j0}, V_{j0}, and D_{-1}.

We finally define theoretical counterparts of real output, real consumption and real investment as, respectively, $\hat{Y}_t = 1/P_t \sum_j p_{jt} Y_{jt}$, $\hat{I}_t = 1/P_t \sum_j P_t^I I_{jt}$, and $\hat{C}_t = 1/P_t \sum_j P_t^C C_t$, where $P_t = \sum_j p_{jt} Y_{jt} / \sum_j p_j^* Y_{jt}$ defines the theoretical counterpart of a Paasch production price index (i.e., the price deflator used in the data).

2.3.4 Price and Interest Premium shocks

The context of a small open economy means that the country has no possibility to influence world prices or the world interest rate. The economy is supposed to take export and import prices as given and to adjust to shocks that occur within world markets. To analyze the macroeconomic dynamics following a terms-of-trade shock, I propose to recall the estimated system of equation (2.3), and to implement it within the theroetical model. Letting $P_{mt} = P_{x*} = 1 \ \forall t$, where P_{x*} denotes the steady-state price of the export good, I can express the theoretical terms of trade as $tot_t = P_{xt}$ and let log deviations from steady-state $log(P_{xt})$ correspond to $\widehat{tot_t}$.

I also make the plaussible assumption that the price of non-tradable good is affected by terms-of-trade shocks, through the following rule :

$$log(P_{nt}) = \rho_n log(P_{nt-1}) + \pi^n \epsilon_t^{tot} + \pi_{lag}^n \epsilon_{t-1}^{tot}, \tag{2.22}$$

assuming the steady-state price P_{n*} is equal to 1. Note that I let the possibility for terms-of-trade shocks to affect the price of the non-tradable good with one time delay. Parameters π^n and π_{lag}^n refer to standard deviations of the terms-of-trade innovation at time t and $t-1$.
The domestic interest rate is given by:

$$r_t = r^* + s_t + \psi(e^{\tilde{D}_t - D^*} - 1) \tag{2.23}$$

where r^* denotes the world interest rate, ψ, a debt premium sensitivity parameter, s_t, the theoretical counterpart of the interest spread included in the SVAR model, and $\tilde{D}_t$ represents the aggregate level of external debt per capita that households assume as exogenous.

2.4 Calibration Strategy and Estimation

2.4.1 Standard parameters

The model admitting a more general technological structure than the standard SGU model is greater in size, with 57 endogenous variables and 46 parameters. Nonetheless, because its structure is directly in line with inpu-output data, the characterization of the steady state is greatly simplified. All parameters of the model that appear in equilibrium conditions evaluated at the steady state (36 parameters) are calibrated, and the remaining (10) parameters, which are σ, ψ, ϕ_j (j=m,x,n), ρ_n, π^n, π_{lag}^n, ρ_ξ and π^ξ, are estimated by matching impulse response functions of macroeconomic variables obtained with the SVAR model. Tables 2.6 and 2.4 summarize the calibration and estimation of all parameters.

The 36 calibrated parameters are α_j, B_j, θ_j, β, δ, γ, P_x^*, P_m^*, P_n^*, τ_j, κ_i^K, ν_{ij}^V, ζ_i^C, $(r^* + s^*)$, and D^*, $\forall i, j \in J$. For some of them, I simply recall the values from Schmitt-Grohé and Uribe, 2018. We let for instance $\gamma = 2$. As well, I let $\alpha_x = \alpha_m = 0.35$, $\alpha_n = 0.25$, $r^* = 0.07$, $\beta = \frac{1}{1+r^*+s^*} = 0.9$ (with $s^* = 0.04$), and $\delta = 0.1$. I also deduce the value of D^* to obtain a trade balance-to-output ratio of 1%. I let θ_j be the share of intermediate consumption among total output given by sector data (presented in section 2.1). Because I assume perfectly divisible goods, I define the units of output in each sector such that $P_{x*} = P_{m*} = P_{n*} = 1$. We let the relative values of B_j determine the sizes of sectors and note that absolute levels of B_j are calibrated to approximate the consumption-output ratio. The values of τ_j are set to 1.455 $\forall j = m, x, n$ to ensure a Frisch elasticity of laborsupply of 2.2. Input-output parameters κ_i, ν_{ij}, and ζ_i are calibrated to match, respectively, the observed investment budget shares ω_{it}^I (supposed as equal for all sectors), the observed intermediate consumption shares of goods used by each sector $\omega_{it}^{V_j}$, and the observed final consumption shares of goods defined previously as ω_{it}^C. In each case, values of the parameters are calibrated under the assumption of steady-state price indexes normalized to 1. The calibration is indeed simplified with $\zeta_i = \left(\omega_{it}^C\right)^{1/\sigma}$, $\kappa_i = \left(\omega_{it}^I\right)^{1/\sigma}$, and $\nu_{ij} = \left(\omega_{it}^{V_j}\right)^{1/\sigma}$.

2.4.2 Estimation

We propose to estimate the set of parameters

$$\Phi = [\sigma\ \phi_m\ \phi_x\ \phi_n\ \psi\ \rho_n\ \pi^n\ \pi_{lag}^n\ \rho_\xi\ \pi^\xi]$$

through the same partial information method as in Schmitt-Grohé and Uribe, 2018. The method consists of matching the theoretical impulse responses

TABLE 2.3: Calibrated parameters

Parameters	Description	Source	Value
γ	CRRA	SGU (2018)	2
δ	Depreciation rate	SGU (2018)	0.1
$r^* + s^*$	Risk-free interest rate + spread	SGU (2018)	0.11
β	Time Discounting rate	SGU (2018)	0.9009
α_x, α_m	Capital shares (X and M sector)	SGU (2018)	0.35
α_n	Capital share (N sector)	SGU (2018)	0.25
P_j^*	Final good prices	set	1
D^*	External debt	calibrated to target TBY = 1%	Table2.9
θ_j	Intermediate consumption share	SGU (2018)	0.5
B_j	Total Productivity parameters	calibrated to target sector shares	Table2.9
τ_j	Utility parameters	SGU (2018)	1.455
ζ_i	Preference parameter	equal to $\left(\hat{\omega}_{it}^{C}\right)^{1/\sigma}$	Table2.10
κ_i	Technological parameter	equal to $\left(\hat{\omega}_{it}^{I}\right)^{1/\sigma}$	Table2.11
ν_{ij}	Technological parameter	equal to $\left(\hat{\omega}_{it}^{V_j}\right)^{1/\sigma}$	Table 2.12

We let $\hat{\omega}$ refer to the observed budget shares given by input-output data. Values are displayed in Tables 2.9 to 2.12 in the Appendix

TABLE 2.4: Estimated parameters

Parameters	Description	Source	Value
σ	CES parameter	estimated	Table2.13
ψ	Debt elasticity parameter	estimated	Table2.13
ϕ_j	Capital adjustment costs	estimated	Table2.13
ρ_n	AR(1) parameter Non-tradable Price	estimated	Table2.13
π_n	Stderr of shock on Non-Tradable Price	estimated	Table2.13
π_{lag}^{n}	Stderr of lagged shock on Non-Tradable Price	estimated	Table2.13
ρ_ξ	AR(1) parameter Nom. Exch. rate	estimated	Table2.13
π^ξ	Stderr of lagged shock on Nom.Exch.rate	estimated	Table2.13
a_{11}	VAR coefficient	SGU (2018)	Table 2.7
a_{12}	VAR coefficient	SGU (2018)	Table 2.7
a_{21}	VAR coefficient	SGU (2018)	Table 2.7
a_{22}	VAR coefficient	SGU (2018)	Table 2.7
π_{11}	VAR coefficient	SGU (2018)	Table 2.7
π_{21}	VAR coefficient	SGU (2018)	Table 2.7
π_{22}	VAR coefficient	SGU (2018)	Table 2.7

implied by terms-of-trade shocks, of output, consumptio, investment, and the real-exchange rate to the empirical responses of the SVAR model. We use the first five years of each of the impulse response functions weighted by the inverse of the width of the 66% confidence interval (denoted below by Δ_{tj}).

We set Φ as the solution that minimizes:

$$Min \sum_{t=0}^{4} \sum_{j=\hat{Y},\hat{C},\hat{I},RER} \frac{1}{\Delta_{tj}} \left| IRF_{tj}^{SOE-IO}(\Phi) - IRF_{tj} \right|$$

where $IRF_{tj}^{SOE-IO}(\Phi)$ and IRF_{tj} respectively denote the impulse response at time t of the variable j following the terms-of-trade shock, obtained through the theoretical SOE-IO and the empirical SVAR model. The weighting factor is defined by the inverse of Δ_{tj}, which represents the width of the 66% confidence intervals of the variable j at time t.

2.5 Results

Results of the estimation are summarized in table 2.5 (details are reported in table 2.13 in the Appendix). The median of capital adjustment costs are close to standard values in the literature (4 to 8). The debt elasticity parameter is 5.13 and the overall degree of elasticity of substitution between goods is estimated at 0.75 (the literature indicates an interval between 0.5 and 1.) Terms-of-trade shocks transmit to the price of the non tradable good, but effects are not persistent (the AR parameter ρ_n is estimated at 0.3). Results by countries are displayed in the Appendix. Figure 2.2 below reports the median of the impulse responses to a 10 percent terms-of-trade shock of the 15 countries in consideration. The proposed SOE-IO model fits relatively better the empirical SVAR predictions compared to the standard SOE model. It predicts lower median responses of real output, real consumption and investment and reproduces the shape of the dynamics of most aggregate variables remarkably well.

Figure 2.3 helps understanding the propagation of terms-of-trade shocks in the domestic economy by presenting impulse responses of marcoeconomic variables disagregated over sectors and goods. It gives for instance details

TABLE 2.5: Results of Estimation

	ϕ_m	ϕ_x	ϕ_n	ψ	σ	ρ_n	π^n	π^n_{lag}	ρ_ξ	π^ξ
Median	8.02	4	4.1	5.13	0.75	0.3	0.03	0.02	0.88	-0.01

Note: The minimization program is solved starting from restricted guess values (and through a CMAES algorithm).

about theoretical impulse responses displayed in Figure 2.2. An increase of the relative price of exportables generates an expansion of production in the export good sector by attracting more resources through higher real remunerations. In parallel, production falls in the import good sector and remains relatively constant in the non-tradable one (second row of the Figure 2.3). Overall, the response of real aggregate output is slightly positive. In order to match this response, the price of the non-tradable good is predicted to increase so as to obtain producers in that sector maintain same quantities of output. The mechanism described is qualitatively similar to the one of Schmitt-Grohé and Uribe, 2018, however, variations appear amplified in the presented model. The higher response of the export good sector (left panel of second row of Figure 2.3) is caused by a more important inflow of labor from the import good sector, that results essentially from the effect of the consumption price index. The real wage is indeed more impacted in the presented model where export goods constitute a significant fraction of domestic consumption.

Both theoretical models predict correctly the increase of real investment following a terms of trade shock that is expected to be persistent (right panel of the third row in Figure 2.2). In each case, the export good sector is predicted to attract more capital resources to the detriment of the import good sector (third row of Figure 2.3). As regards real consumption, the presented model does slightly better in reproducing the shape of the empirical response (left panel of the third row in Figure 2.2). At the disagregated level, real consumption of import goods decreases contrary to real consumption of export and non-tradable goods (fourth row of Figure 2.3). Such a result has to do with the degree of elasticity of substitution which is relatively low. Indeed, as discussed in the last section, the median impulse response of the model is very close to the perfect complement case; the degree of elasticity of substitution needs to increase significantly to obtain a real consumption of export and non-tradable goods decrease to the benefit of relatively cheaper import goods.

This analysis of the quality of fit of the theoretical models to the data, should be completed by a country-by-country comparison of shares of variances of macroeconomic indicators explained by terms-of-trade shocks. Theoretical shares of variances are defined as ratios of theoretical variances conditionnal on terms of trade shocks to unconditionnal variances obtained with the SVAR model. Figure 2.4 displays the empirical shares of variance of real output against the theoretical ones obtained with the standard SOE model and the alternative SOE-IO version proposed. Similar figures for real consumption, real investment, the trade balance-to-output ratio and the real exchange rate are presented in Figure 2.5. If the points lie on the 45 degree line, theoretical predictions confirm empirical ones for each country. As can be seen, the presented SOE-IO model tends to confirm most of the different impacts of terms of trade shocs on real GDP predicted by the SVAR model by ordering each point around the 45 degree line. It also predicts better the country responses of real consumption and real investment than the standard model, in view of a more apparent positive realtionship (first and second row of Figure 2.5). Concerning the real exchange rate, results are obtained by matching impulse responses of an AR(1) process with the data. Some refinements remain however necessary to bring the model closer to the observed dynamics of the trade-balance-to-output ratio.

Should we conclude that accounting for the country-specific input-output

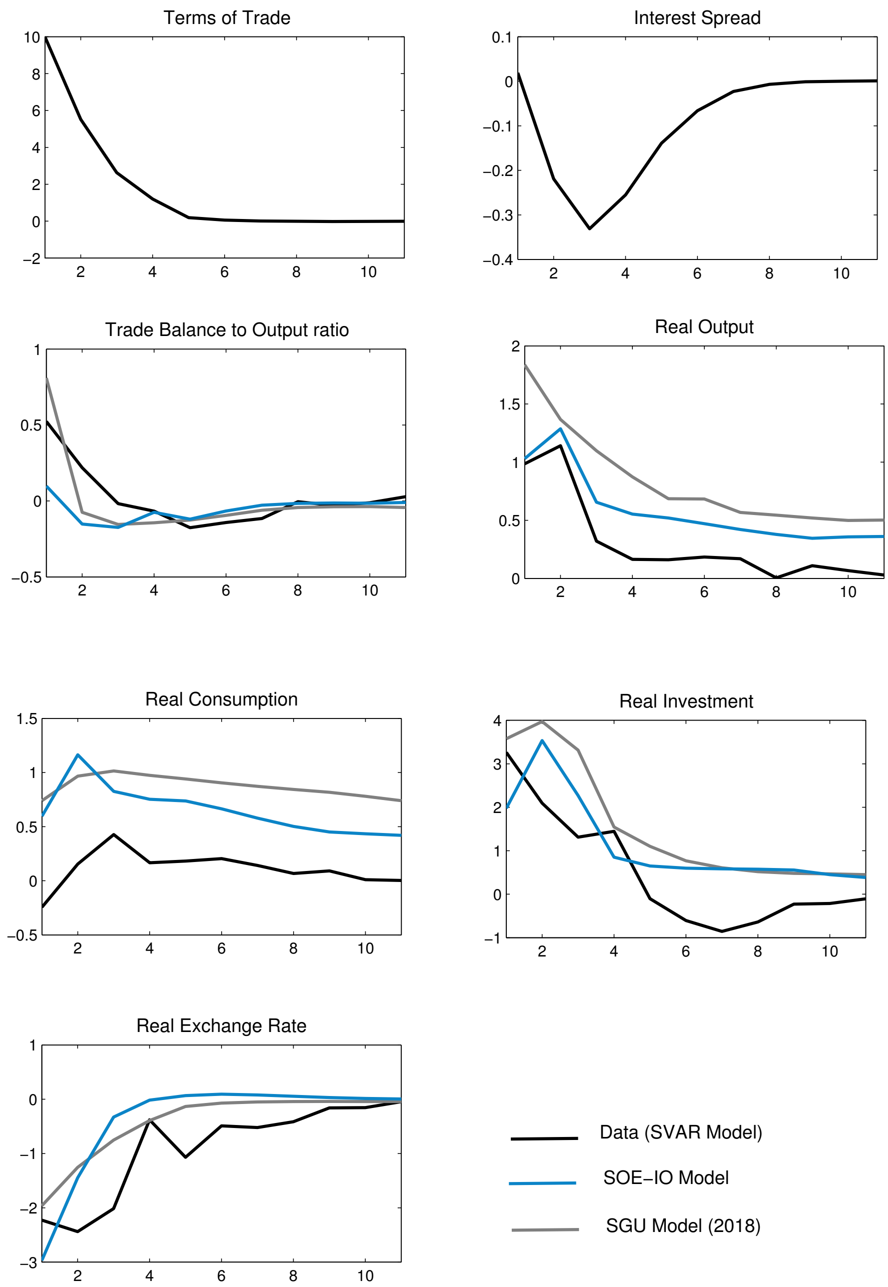

FIGURE 2.2: Impulse responses following a 10% terms-of-trade shock

Note: Impulse responses are represented as point-by-point medians across countries. The country-specific impulse responses are presented in appendix with 66% confidence intervals.

structure is the main reason of the imrpovement of the quality of fit ? The answer is actually no at this step given the models differ in several respects. To clarify the contribution of the input-output structure, we propose therefore to perform some simulation exercises.

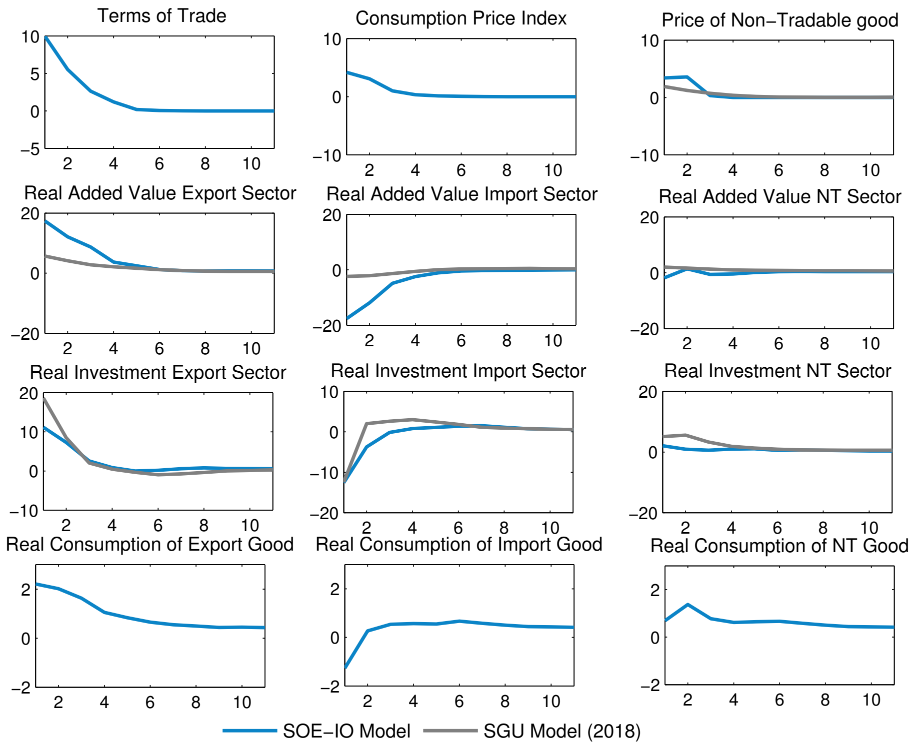

FIGURE 2.3: Theoretical impulse responses following a 10% terms-of-trade shock for additionnal variables

Note: Impulse responses are represented as point-by-point medians across countries.

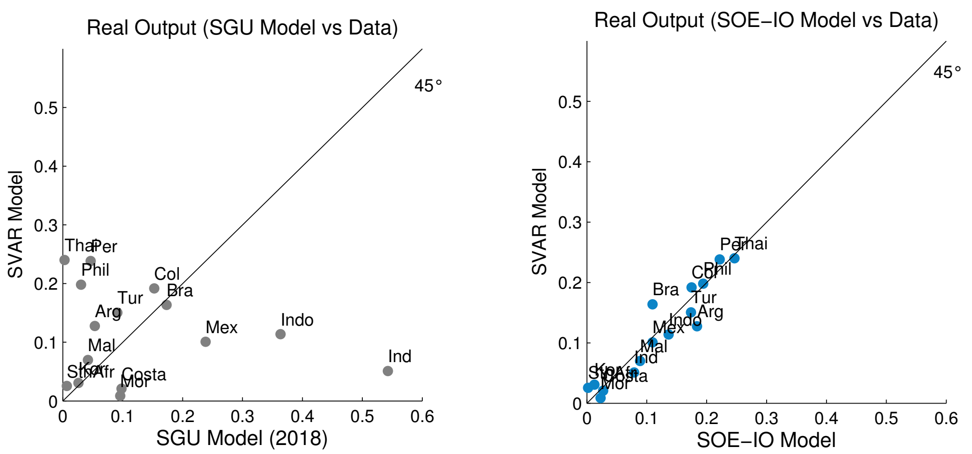

FIGURE 2.4: Comparison of Variances of Real GDP

2.6 The role of the input-output structure

2.6.1 Analysis within a domestic economy

The goal of this section is to quantify the role of the input-output structure. In a first subsection, the idea is to analyse within a domestic economy how the

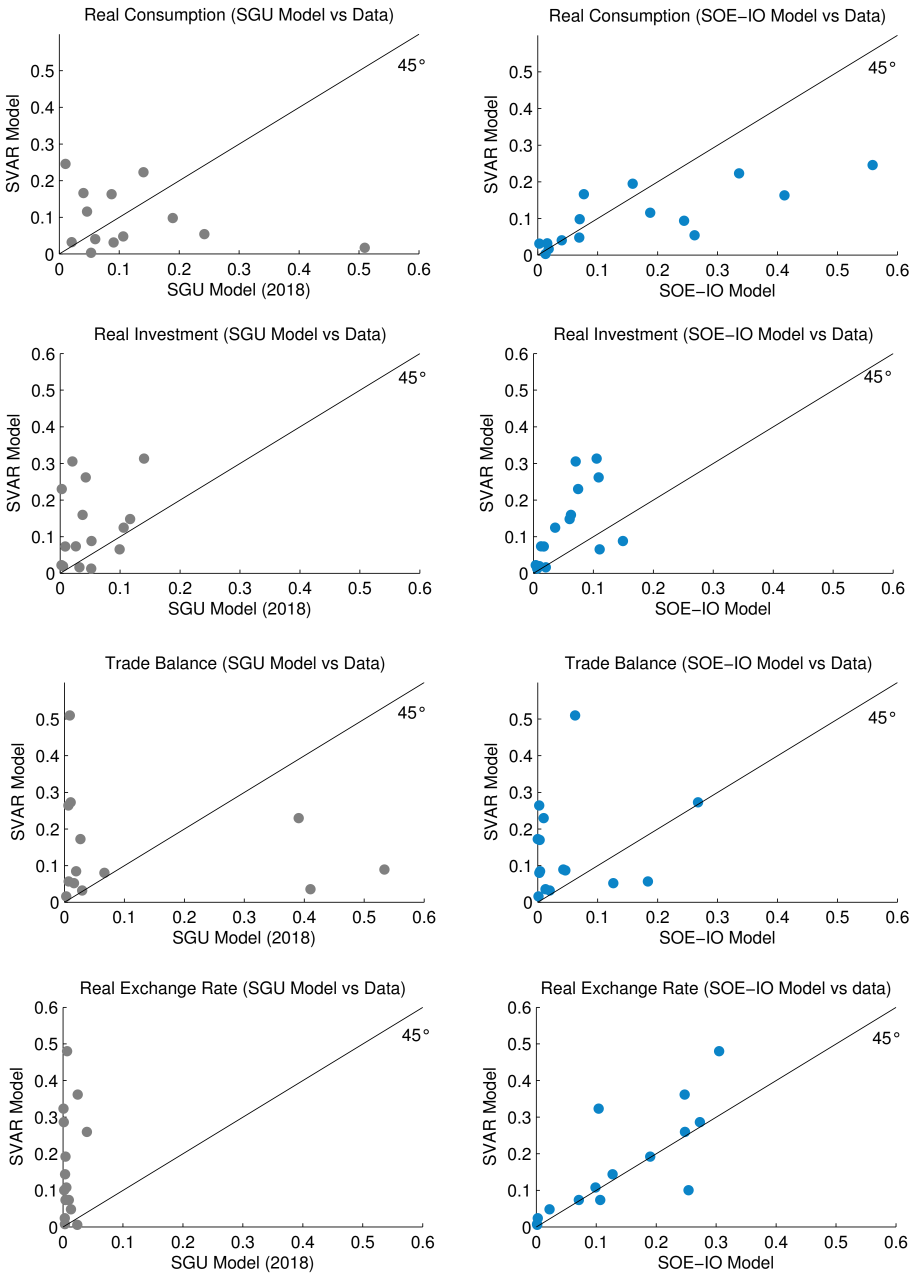

FIGURE 2.5: Comparison of Variances of Real Macro Variables

structure of the global demand for intermediate, investment and consumption goods affects the dynamics in response to terms-of-trade shocks. The second subsection addresses a global comparative analysis over the different countries of the sample.

In the literature using the standard SOE model, the greater the size of the export good sector, the greater the favorable impact on the domestic country following a relative price increase of the export good. The role of the input-output structure of the economy is precisely to amplify or dampens this positive impact (and in a general manner, the impact of a sector size). Assuming two countries which differ only across their input-output structure, the one which employs more intensively the goods getting more expensive after a given shock, with limited possibilities to substitute, should obviously experience the lowest economic expansion. Production is indeed discouraged through both input prices and through the higher consumption price index which causes to reduce real remunerations. This first subsection quantifies the effects related to higher prices of capital goods, intermediate goods, and consumption goods.

Starting from calibrated and estimated models, we consider 3 alternative input-output structures for each country. The first one (scenario 1) assumes that each country uses no export goods as intermediates; i.e., $\nu_{xj} = 0$, $\forall j = m, x, n$. The second one (scenario 2) considers no use of export goods in terms of intermediate and capital goods; i.e., $\nu_{xj} = 0$ and $\kappa_x = 0$, $\forall j = m, x, n$. The last one (scenario 3) considers no use of export goods at all; i.e., $\nu_{xj} = 0$, $\kappa_x = 0$, and $\zeta_x = 0$, $\forall j = m, x, n$. In each scenario, it is assumed that the use of non-tradable and import goods remains proportionnal.

The median impulse responses corresponding to the fitted SOE-IO model and to each scenario are presented in Figure 2.6. As expected, the less the export good is employed within the domestic economy, the larger the resulting expansion from the relative increase of the export good price (conversely, from scenario 3 to scenario 1, one obtains the dampening effects of a more intensive use). Excluding the use of exports as intermediate goods produces a significant positive effect on real output, which can be understood through equations derived from the producers program. Indeed, when sectors use export goods as intermediates, the increase of production costs resuling from

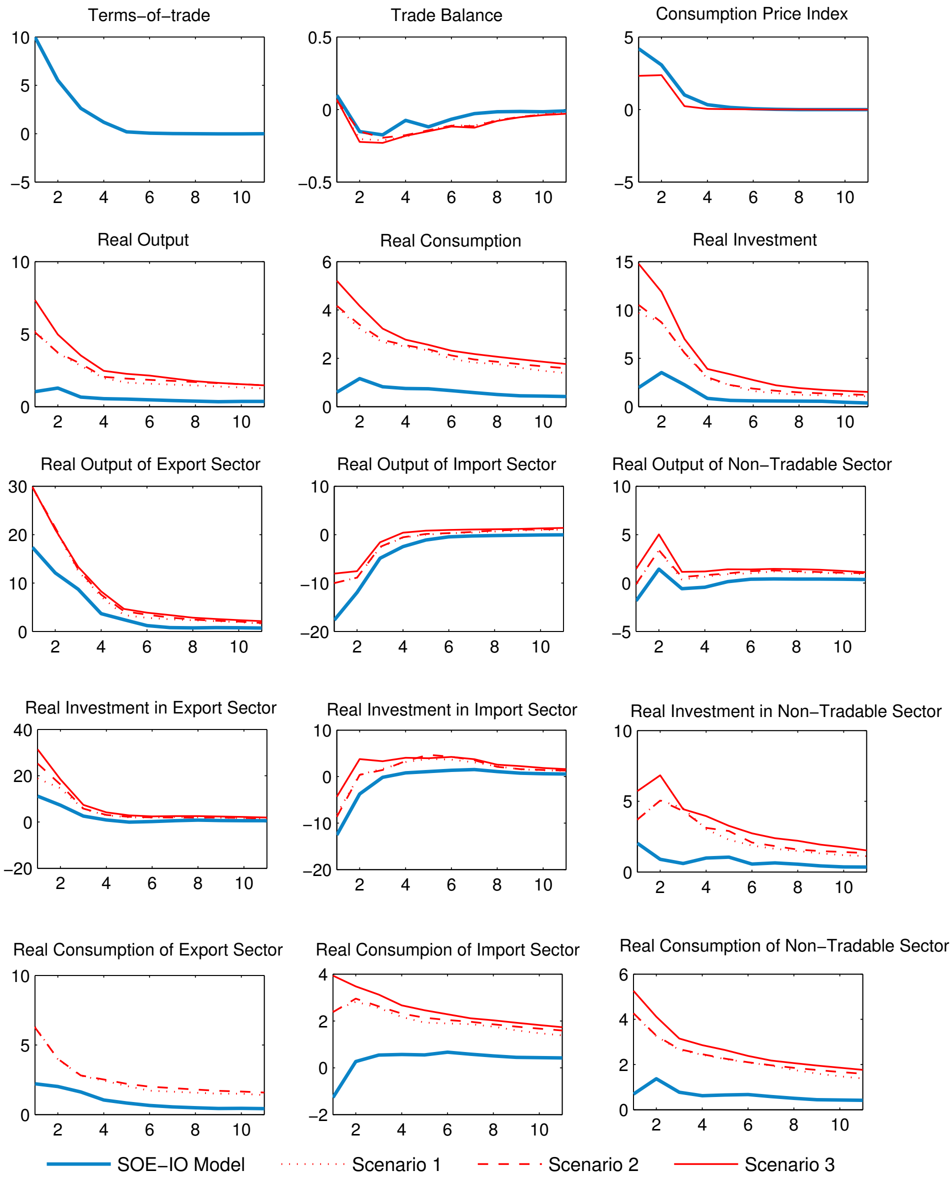

FIGURE 2.6: Theoretical impulse responses for different levels of use of exports

Note: Impulse responses are represented as point-by-point medians across countries for each scenario; scenario 1 being the one where exports are not employed as intermediates, scenario 2 being the one where exports are neither used as intermediate nore as capital goods, and scenario 3 being the one where export goods are not employed at all.

the terms-of-trade shock causes an incentive to reduce the quantities of intermediate goods, which in turn makes labor less productive. Firms decrease therefore their use of labor, so that output declines immediately in each sector. As regards the marginal effect of excluding export goods from capital inputs (scenario 2), its size appears almost neglible for all macro indicators.

This is however not the case for what concerns the marginal effect of eliminating exports from the consumption basket (scenario 3). It can indeed be noticed that the consumption price index increases less, since in that case, it is affected by the non-tradable price only. Note that the increase of the price of the non tradable good should not necessarily be viewed as a consequence of higher production costs, but also as the result of the markets equilibrium dynamics.

2.6.2 A cross-country analysis

In this section, I evaluate whether the heterogeneity in terms of input-output structure across countries plays an important role in theoretical predictions presented so far. Expressed differently, do the heterogenous reponses across countries discussed in the previous section depend significantly on the input-output structure of their economy ? One way to address this question is to consider once again the calibrated and estimated models for the 15 countries, and to analyze the effects of inter-changing their respective input-output structure. Table 2.6 recalls the median proportions of export goods used domestically (from Table 2.1) and presents two alternative scenarios in terms of input-output structure for each country: the first involves increasing proportions of export goods employed in the production system and consumed by households up to the same levels as Malaysia (sample maximum), and the second involves decreasing the proportions down to those of the Philippines (sample minimum).

TABLE 2.6: Domestic Use of Export goods (%)

	Sectors				
Country	M	X	N	Invest.	Cons.
Median	26	49	25	18	28
Scenario 1 (Malysia)	22	66	40	23	35
Scenario 2 (Philippines)	4	43	10	14	3

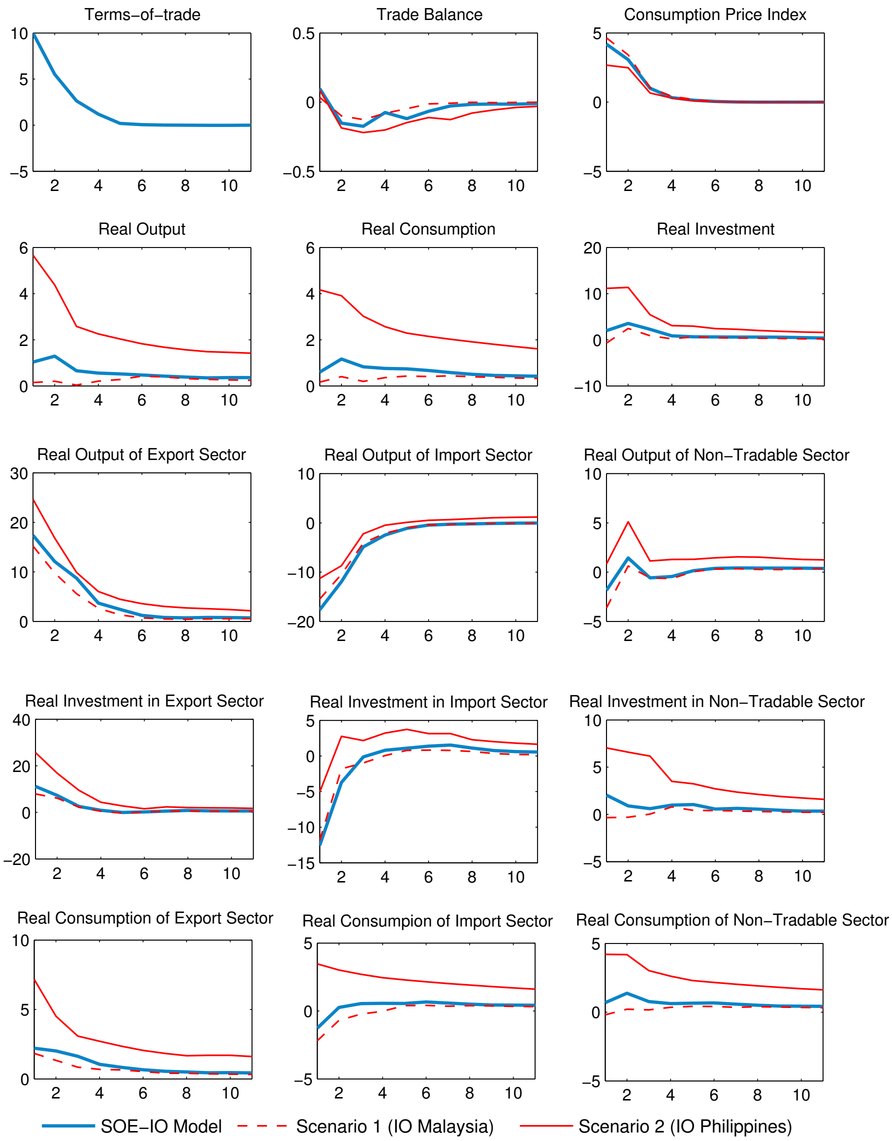

FIGURE 2.7: Theoretical impulse responses for different levels of use of exports

Note: Impulse responses are represented as point-by-point medians across countries for each scenario; scenario 1 assumes the input-output structure of Malaysia in each country, and scenario 2, the input-output structure of Philippines in each country.

Figure 2.7 displays median impulse responses of the fitted SOE-IO model and the two scenarios of the simulation exercise for the enitre sample of countries. If all countries had an input-output structure comparable to the one of Malaysia, the growth cycle would be offset by the increase of domestic prices (on impact of a terms-of-trade shock of 10%, real output drops of -1.6%). The consumption price index for example increases above 2% (instead of 0.9%).

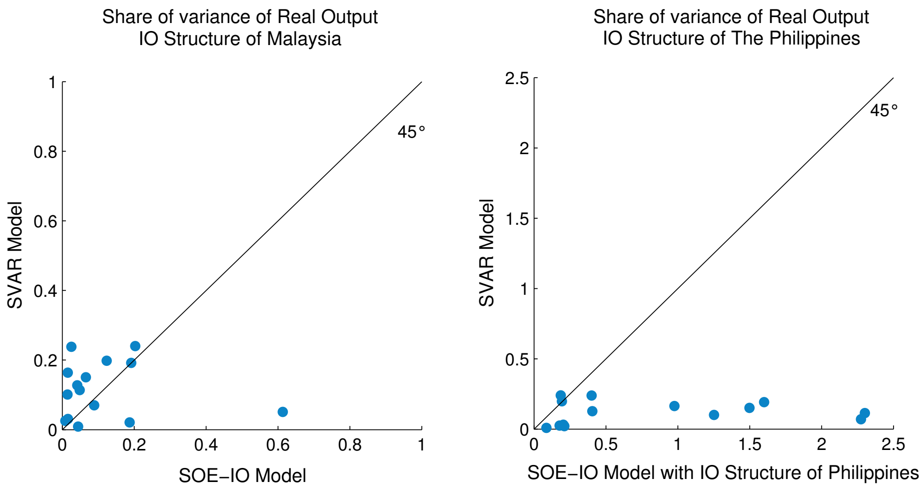

FIGURE 2.8: Comparison of Variances of Real GDP under input-output structures of Malaysia and Philippines

On the opposite, if all countries had an input-output structure comparable to the one of Philippines, the predicted mediane growth rate of the sample would be this time around 5% in real terms. Hence, differences across countries in terms of production and global demand structures influence considerably the impact of terms-of-trade shocks. The comparision of theoretical and empirical shares of variance realized by Schmitt-Grohé and Uribe, 2018 should thus necessarily account for the country specific input-output structures. Figure 2.8 confirms this necessity. It shows that shares of variances can be drastically altered when assuming unconform economic structures.

The important role of the input-output structure can also be confirmed in a simple way. The median response of output calculated over countries with a rate of domestic use of exports below the sample median of 29% (see Table 2.1) reaches a level of 1.6% on impact of a 10% terms-of-trade shock, whereas the median calculated for countries above 29% reaches only 0.7% on impact.

2.7 The role of the elasticity of substitution

This section presents a sensitivity analysis of results with respect to different degrees of elasticity of substitution between goods. Indeed, if the role of terms-of-trade shocks in explaining business cycles of an emerging country directly related to the global supply and demand structure of its economy, then it necessarily depends also upon the nature of the goods produced, employed as inputs and consumed. Specifically, the more goods are substitutes, the more a country can benefit from a price increase on world markets. A value of the degree of elasticity of substitution approaching zero for example, corresponds to the perfect complement case where the dampening effect of the input-output channel is maximal. On the opposite, an extremely high value corresponds to the perfect substitute case where the input-output structure does not influence the role of terms-of-trade shocks anymore.

The sample median of the degrees of elasticity of substitution has been reported previously to be 0.75. Departing from the calibrated and estimated models as in the previous section, I propose to simulate impulse responses for different values of the degree of elaticity of substitution, everything equal.

Results are displayed in Figure 2.9. The case of perfect of substitute goods constitutes, as expected, the upper-bound limit of the economic expansion generated by a 10% terms-of-trade shock. Real output increases on impact by approximately 11%, which appears almost two times more than in the case studied previously under the assumption of no domestic absorption of export goods (scenario 3 in section 6.1). Indeed, perfect substitution implies stable price indexes, whereas in the previous case of no absorption of export goods, the increase of the non-tradable price affects production and consumption costs. As regards the case of perfect complementarity, results appear close to median impulse responses of estimated models. The response

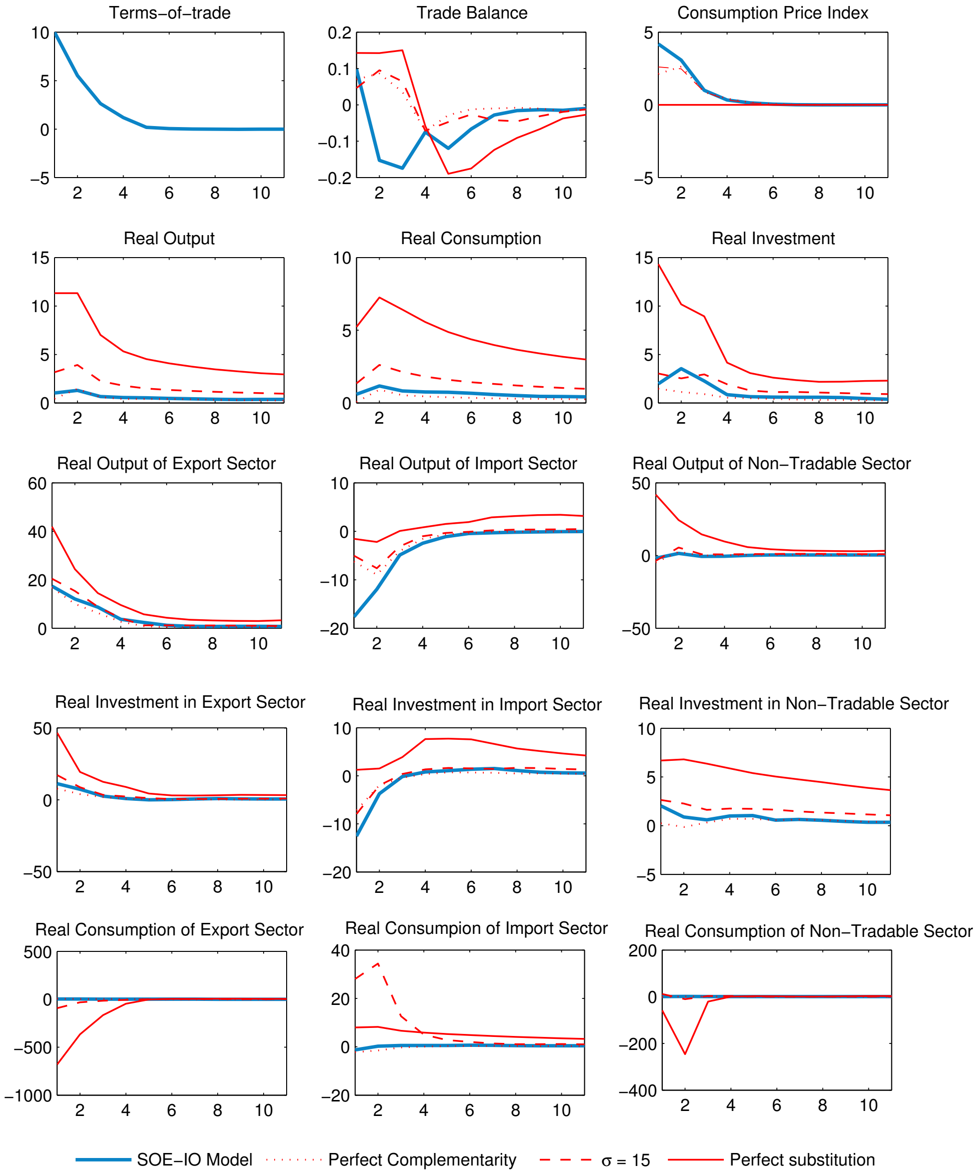

FIGURE 2.9: Theoretical impulse responses for different levels of use of exports

Note: Impulse responses are represented as point-by-point medians across countries for each scenario; the figure presents results of the model and results of simulations when changing the elasticity of substitution between goods.

of real output reaches 3.2% on impact when the degree of elasticity of substitution between goods is supposed equal to 15, hence, almost three times the growth impact obtained through the median response of countries.

2.8 Conclusion

This article extends the study of Schmitt-Grohé and Uribe, 2018 concerning the impacts of terms-of-trade shocks on business fluctuations of emerging and resource-limited countries. Indeed, it appears that theoretical and empirical predictions do not converge at the country-by-country level. This disconnect problem might be resolved either by dampening the theoretical effects of terms-of-trade shocks or by increasing the empirical effects related to shocks on world prices as proposed by Fernández, Schmitt-Grohé, and Uribe, 2017. In this paper, I focus on how to mitigate the theoretical over-prediction of macroeconomic fluctuations in emerging and resource-limited countries following a price increase of their export goods on world markets. I study this question through an alternative multisector SOE model which can be calibrated on real input-output data with precision. This allows to better account for the structure of the domestic global demand, and to set the right level of domesic absorption of export goods (29% on average versus a calibration of only 5% in Schmitt-Grohé and Uribe, 2018). Depending indeed on how much a country uses its own export goods as intermediate, capital or consumption goods (under the hypothesis of imperfectly substitute goods), the growth effects of a terms-of-trade shock can either be dampened or amplified through the channel of production costs.

The proposed model appears to resolve the disconnect problem with theoretical impulse responses and shares of variances closer to the empirical results. It is then used to evaluate the role of the input-output structure regarding the hetergenous responses to terms-of-trade shocks across countries. The analysis confirms in several ways that accounting for the right specific input-output structure of an economy is fundamental to understand and measure the domestic impacts of shocks on export and import prices.

The proposed SOE model confirms the minor impacts of terms-of-trade shocks on macroeconomic fluctuations of emerging countries predicted by an SVAR model. It would be interesting to analyze what this SOE model teaches about the conclusions of Fernández, Schmitt-Grohé, and Uribe, 2017 concerning the greater impacts of shocks on commodity prices.

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2.9 Appendix

A1.Description of Data Sources

The paper uses the same data as Schmitt-Grohe and Uribe (2018) for the SVAR model, for instance World Bank's World Development Indicators (WDI) database. The raw data from this source consists of the following annual time series.

- Net barter terms of trade index (2000 = 100), TT.PRI,MRCH.XD.WD
- GDP per capita in constant local currency units, NY.GDP.PCAP.KN
- Gross capital formation (% of GDP), NE.GDI.TOTL.ZS
- Imports of goods and service (% of GDP), NE.IMP.GNFS.ZS
- Exports of goods and service (% of GDP), NE.EXP.GNFS.ZS
- Households consumption expenditure (% of GDP), NE.CON.PETC.ZS
- Consumer price index (2010 = 100), FP.CPI.TOTL.
- Official exchange rate (LCU per US dollars, period average), PA.NUS.FCRF
- Real effective exchange rate index (2005 = 100), PX.REX.REER.

The paper uses also input-output data of year 2000 to calibrate the SOE-IO model:

- OECD Input-Output Database is used for Argentina, Colombia, Costa-Rica, Peru, Malaysia, Morocco, The Philippines, Thailand, and South Africa.
- WIOD data for Brazil, India, Indonesia,South Korea, Mexico, and Turkey.

The study of correlations of prices indexes in section 2 uses data from:

- Penn World Tables for the export and consumption price index.
- WDI for the Wholesle price and Trading Economics for the Production price index

2.10 Appendix

A2.The empirical SVAR model: Estimated parameters

TABLE 2.7: The joint law of motion of the terms of trade and interest spread: Parameter estimates of SGU (2018)

Country	a_{11}	a_{12}	a_{21}	a_{22}	π_{11}	π_{21}	π_{22}
Argentina	0.3932	0.7545	-0.0204	0.5429	0.0783	0.0033	0.0127
Brazil	0.6094	1.5689	-0.0457	0.4277	0.0802	-0.0014	0.0124
Columbia	0.2898	0.6119	0.0002	0.5269	0.0818	-0.0016	0.0132
Costa Rica	0.5664	1.3821	-0.0457	0.4918	0.0695	-0.0007	0.0126
India	0.6051	1.6957	-0.0170	0.5401	0.0858	0.0004	0.0131
Indonesia	0.5654	-1.0671	0.0220	0.4588	0.1066	0.0002	0.0127
Korea	0.6595	1.2577	-0.0717	0.5465	0.0414	0.0013	0.0126
Malaysia	0.4990	0.6063	-0.0236	0.5327	0.0533	0.0019	0.0130
Mexico	0.7450	-1.6568	0.0106	0.5461	0.0876	-0.0018	0.0131
Morocco	0.4358	-0.5860	-0.0034	0.5293	0.0609	0.0045	0.0125
Peru	0.5444	0.4493	-0.0395	0.4433	0.0842	-0.0030	0.0124
Philippines	0.5452	0.5154	-0.0346	0.4725	0.0832	0.0009	0.0127
South Africa	0.7374	0.9740	-0.0486	0.5276	0.0376	0.0019	0.0128
Thailand	0.6171	1.2616	-0.1072	0.4672	0.0352	-0.0006	0.0120
Turkey	0.3270	0.6590	-0.0523	0.5190	0.0445	-0.0004	0.0130
Median	0.5654	0.6590	-0.0346	0.5269	0.0783	0.0002	0.0127
Med Abs Dev.	0.0664	0.5987	0.0176	0.0192	0.0093	0.0016	0.0003

A3. The theoretical model:Calibrated and estimated parameters

TABLE 2.8: Sector shares by country

Country	$\rho*$	s_m	s_x	s_n
Argentina	5.9	21	29	49
Brazil	1.9	30	17	53
Colombia	5.7	14	36	51
Costa Rica	15	30	35	35
India	4	19	31	50
Indonesia	15	13	35	51
Korea	8.5	20	30	50
Malaysia	15	31	45	25
Mexico	5.8	19	31	50
Morocco	15	38	21	42
Peru	10	27	26	48
Philippines	14	40	11	49
Sth Africa	14	15	36	50
Thailand	15	22	37	41
Turkey	17	23	26	51
Average	10.8	24.1	30.3	45.9
Std Dev.	5.1	8.2	8	7.3

Note: Sector size s_m, s_x, and s_n are all expressed in percentage.

TABLE 2.9: Country specific calibrated parameters

Country	$D*$	B_m	B_x	B_n	θ_m	θ_x	θ_n
Argentina	0.2	1.65	2.04	2.05	53	48	28
Brazil	0.23	2.02	1.85	2.2	58	56	42
Colombia	0.22	1.67	1.98	2.15	58	46	35
Costa Rica	0.16	1.87	1.79	1.87	47	56	31
India	0.16	1.69	1.91	2.05	51	52	38
Indonesia	0.06	1.48	1.63	1.65	61	52	41
Korea	0.07	1.6	1.75	1.8	59	65	42
Malaysia	0.036	1.59	1.63	1.50	59	69	50
Mexico	0.11	1.6	1.83	1.72	60	45	28
Morocco	0.19	1.89	1.87	1.92	47	59	31
Peru	0.16	1.85	1.78	2.06	45	62	37
Philippines	0.17	1.98	1.5	2.04	55	70	33
Sth Africa	0.15	1.7	1.82	2.07	64	60	47
Thailand	0.1	1.75	1.77	1.9	61	61	42
Turkey	0.13	1.65	1.95	1.98	53	60	47
Average	0.14	1.7	1.9	1.9	55	57	38
Std Dev.	0.06	0.1	0.1	0.2	5.9	7.9	7.2

TABLE 2.10: Share of final consumption

Country	ω_m^C	ω_x^C	ω_n^C	C^*/Y^*
Argentina	25	25	50	0.87
Brazil	24	20	56	0.85
Colombia	20	30	50	0.9
Costa Rica	35	26	40	0.79
India	14	36	50	0.82
Indonesia	20	23	57	0.58
Korea	18	18	64	0.63
Malaysia	25	34	41	0.51
Mexico	27	20	53	0.72
Morocco	27	30	43	0.82
Peru	22	20	58	0.82
Philippines	45	5	50	0.86
South Africa	13	31	56	0.82
Thailand	17	34	49	0.71
Turkey	26	21	54	0.75

TABLE 2.11: Shares of investment

Country	ω_m^I	ω_x^I	ω_n^I
Argentina	26	11	63
Brazil	19	20	61
Colombia	24	12	65
Costa Rica	32	65	3
India	20	19	61
Indonesia	21	3	77
Korea	14	29	57
Malaysia	33	22	44
Mexico	10	27	63
Morocco	48	5	48
Peru	37	1	62
Philippines	35	15	50
South Africa	29	22	48
Thailand	32	25	43
Turkey	31	11	57

TABLE 2.12: Shares of intermediate consumption

Country	$\omega_m^{V_m}$	$\omega_x^{V_m}$	$\omega_x^{V_m}$	$\omega_m^{V_x}$	$\omega_x^{V_x}$	$\omega_n^{V_x}$	$\omega_m^{V_n}$	$\omega_x^{V_n}$	$\omega_n^{V_n}$
Argentina	25	56	19	46	33	21	35	25	40
Brazil	33	48	19	63	19	18	43	21	36
Colombia	25	56	19	46	33	21	27	18	55
Costa Rica	54	38	8	63	11	26	39	30	30
India	25	42	33	56	28	17	30	27	43
Indonesia	16	40	44	39	28	33	30	30	39
Korea	25	63	13	60	22	18	29	26	45
Malaysia	33	66	1	22	67	11	37	39	24
Mexico	33	48	19	57	29	14	39	24	37
Morocco	47	41	12	75	11	14	63	21	17
Peru	29	42	29	66	9	25	34	19	47
Philippines	50	42	8	71	5	24	65	10	25
South Africa	22	54	24	35	38	27	19	31	50
Thailand	26	53	21	61	30	9	34	38	28
Turkey	26	57	17	51	27	22	25	23	52

TABLE 2.13: Country specific estimates

Country	ϕ_m	ϕ_x	ϕ_n	ψ	σ	ρ_n	π^n	π^n_{lag}	ρ_ξ	π^ξ
Argentina	2.12	1.08	2.04	5.13	0.95	0.05	0.05	0.05	0.54	-0.21
Brazil	8.02	0.13	7.95	7.11	0.95	0.1	0.09	0.03	0.99	-0.02
Colombia	15.5	2.26	0.1	5	0.5	0.35	0.02	0.03	0.995	0.01
Costa	10.79	15.65	10.41	0.31	0.25	0.31	-0.05	-0.01	0.975	-0.005
India	4.05	3.98	4	25	0.75	0.51	0.045	0.03	0.65	0.05
Indonesia	24.1	25.78	25.08	4.95	0.2	0	0.06	0.02	0.88	0.05
Korea	24.87	25.02	23.56	0.25	0.1	0.45	0	0.03	0.85	-0.015
Malaysia	44.78	4.2	43.1	15	0.15	0.3	0.07	0	0.5	0.045
Mexico	24.1	25.1	25.61	10	0.95	0.05	0.03	0.03	0.51	-0.02
Morocco	4.02	1.1	3.95	4.06	0.95	0.05	-0.015	-0.015	0.5	-0.02
Peru	0.6	4	0.45	5	0.95	0.9	0.015	0.015	0.95	0.06
Philippines	4.21	2.1	1.94	10	0.95	0.95	-0.01	0.045	0.9	0.05
South Africa	1.95	10	4.1	2.02	0.2	0.1	0.03	0.005	0.99	0.02
Thailand	15.62	14.16	4.5	10	0.95	0.99	-0.03	-0.02	0.99	-0.04
Turkey	0.5	0.11	0.1	15	0.5	0.15	0.03	0	0.71	-0.02
Mediane	8.02	4	4.1	5.13	0.75	0.3	0.03	0.02	0.88	-0.1

Note: Parameters are computed using the CMA-ES and Csminwel algorithm. Interval bounds are constrained to [0.01, 50]. Remind also that $\sigma_{CES} = \sigma_C = \sigma_I = \sigma_V, \forall j = m, x, n$.

A6. The theoretical model: Resolution

Producers

The production function is given by:

$$Q_{jt} = B_{jt}[K_j(X_t)^{\alpha}(A_t L_{jt})^{1-\alpha}]^{1-\theta} V_j(X_t)^{\theta} \tag{2.24}$$

where Q_{jt}, $V_j(X_t)$, $K_j(X_t)$, and L_{jt} denote respectively gross production, aggregate intermediate consumption, aggregate fixed capital, and labor employed by sector j at time t. The level of aggregate capital and intermediate consumption in each sector is expressed as a function of quantities of goods produced in the economy $X_t = (X_{mt}, X_{xt}, X_{nt})$. Producers chose $V_j(X_t)$, $K_j(X_t)$, and L_{jt} so as to maximize:

$$\Pi_{jt} = p_{jt} Q_{jt} - u_{jt} K_j(X_t) - w_{jt} L_{jt} - P_t^{V_j} V_j(X_t)$$

where u_{jt} denotes the capital remuneration rate paid by sector j, $P_t^{V_j}$ is the price index of the intermediate good basket used by sector j, w_{jt} is the wage rate paid, and p_{jt} denotes the price of good j at time t. The first-order conditions of the Producer are given by:

$$p_{jt} Q_{jK}[K_j(X_t), L_{jt}, V_j(X_t)] = u_{jt} \tag{2.25}$$

$$p_{jt} Q_{jL}[K_j(X_t), L_{jt}, V_j(X_t)] = w_{jt} \tag{2.26}$$

$$p_{jt} Q_{jV}[K_j(X_t), L_{jt}, V_j(X_t)] = P_t^{V_j} \tag{2.27}$$

Households

Households maximize the following objective function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{[C_t - G(L_{mt}, L_{xt}, L_{nt})]^{(1-\gamma)} - 1}{1-\gamma} \tag{2.28}$$

where C_t is given by:

$$C_t = (\zeta_m C_{mt}^{\rho} + \zeta_x C_{xt}^{\rho} + \zeta_n C_{nt}^{\rho})^{1/\rho} \tag{2.29}$$

and where:

$$G(L_{mt}, L_{xt}, L_{nt}) = \frac{L_{mt}^{\tau_m}}{\tau_m} + \frac{L_{xt}^{\tau_x}}{\tau_x} + \frac{L_{nt}^{\tau_n}}{\tau_n} \tag{2.30}$$

Simplifying notations with $K_{jt} = K_j(X_t)$ and $I_{jt} = I_j(X_t)$, the sequential budget constraint is defined as:

$$P_t^C C_t + \sum_j P_t^{I_j} I_{jt} + \phi_j(K_{jt+1} - K_{jt}) = \frac{\epsilon_{t+1} D_{t+1}}{1+r_t} - \epsilon_t D_t + \sum_j u_{jt} K_{jt} + w_{jt} L_{jt}, \tag{2.31}$$

The law of motion for capital K_{jt} is given by:

$$K_{jt+1} = (1-\delta) K_{jt} + I_{jt} \tag{2.32}$$

This equation is to be substituted in the previous sequential budget constraint.

Derivation of first order conditions:

First order conditions with respect to consumption:

$$\frac{U_C(C_t, L_{mt}, L_{xt}, L_{nt})}{P_t^C} = \lambda_t \tag{2.33}$$

where U_C refers to the marginal utility of consumption C_t. First order conditions with respect to labor L_{jt}:

$$-U_{L_j}(C_t, L_{mt}, L_{xt}, L_{nt}) = \lambda_t w_{jt} \tag{2.34}$$

which means

$$L_j{}^{\tau_j - 1} = \frac{w_{jt}}{P_t^C} \tag{2.35}$$

First order conditions with respect to external debt:

$$\lambda_t \xi_t = \beta(1 + r_t) E_t \lambda_{t+1} \xi_{t+1} \tag{2.36}$$

First order conditions with respect to capital K_{jt+1}, $\forall j = m, x, n$:

$$\lambda_t [P_t^{I_j} + \phi_j(K_{jt+1} - K_{jt})] = \beta E_t \lambda_{t+1} [u_{jt+1} + (1 - \delta) P_{t+1}^{I_j} + \phi_j(K_{jt+2} - K_{jt+1})] \tag{2.37}$$

At this step the steady-state equilibruim value of K^*, C^*, Y^* and I^* are conditionnal on values of P_t^C and $P_t^{I_j}$. In other words, if index prices are known, then steady-state values of macro variables can be easily solved for.

Intra-temporal General equilibrium:

During eah period t, the following system of equation holds.

$$\omega_{it}^{C} P_t^C C_t + \sum_j \omega_{it}^{I_j} P_t^{I_j} I_{jt} + \sum_j \omega_{it}^{V_j} P_t^{V_j} V_{jt} + NX_{it} = p_{it} Q_{it} \tag{2.38}$$

for $i, j = m, x, n$. The amount NX_{it} denotes net exports of good i at time t, and ω_{it}^{C}, $\omega_{it}^{I_j}$, and $\omega_{it}^{V_j}$ denote respecively optimal budget shares of final consumption, investment, and interemdiate consumption spent on good i. Letting $C(X_t)$, $I_j(X_t)$, and $V_j(X_t)$ be given by a CES Argminton aggregator, Armington, 1969), and assuming that $I_j(X_t)$ is the same $\forall j$:

$$C_t = (\zeta_m C_{mt}^{\rho} + \zeta_x C_{xt}^{\rho} + \zeta_n C_{nt}^{\rho})^{1/\rho} \tag{2.39}$$

where C_{mt} is the domestic quantity of consumption of the import good (note that C_{mt} is more convenient than $C(X_{mt})$)

$$I_t = (\kappa_m I_{mt}^{\rho} + \kappa_x I_{xt}^{\rho} + \kappa_n I_{nt}^{\rho})^{1/\rho} \tag{2.40}$$

$$V_j t = \left(\nu_{mj} V_j (X_{mjt})^{\rho} + \nu_{xj} V_j (X_{xjt})^{\rho} + \nu_{nj} V_j (X_{njt})^{\rho}\right)^{1/\rho}, \tag{2.41}$$

Households chose C_{mt}, C_{xt}, C_{nt} which maximize C_t, or equation (3.14) under the budget constraint:

$$p_{mt} C_{mt} + p_{xt} C_{xt} + p_{nt} C_{nt} = P_t^C C_t \tag{2.42}$$

Households chose I_{mt}, I_{xt}, I_{nt} which maximize I_t under the budget constraint:

$$p_{mt} I_{mt} + p_{xt} I_{xt} + p_{nt} I_{nt} = P_t^I I_t \tag{2.43}$$

Households chose $V_j(X_{mjt})$, $V_j(X_{xjt})$, and $V_j(X_{njt})$ which maximize V_jt, $\forall j = m, x, n$ under the budget constraint:

$$p_{mt}V_j(X_{mjt}) + p_{xt}V_j(X_{xjt}) + p_{nt}V_j(X_{njt} = P_t^{V_j}V_jt \tag{2.44}$$

It will be shown next that maximizing (3.14), (3.15), and (2.41), with respect to (2.42), (2.43), and (2.44) gives:

$$P_t^C = \left(\sum_i \zeta_i^\sigma p_{it}^{1-\sigma_C}\right)^{1/(1-\sigma)} \quad \omega_{it}^C = \zeta_i^\sigma \left(\frac{P_t^C}{p_{it}}\right)^\sigma, \tag{2.45}$$

$$P_t^{I_j} = \left(\sum_i \kappa_{ij}^{\sigma_{I_j}} p_{it}^{1-\sigma}\right)^{1/(1-\sigma)} \quad \omega_{it}^{I_j} = \kappa_i^\sigma \left(\frac{P_t^{I_j}}{p_{it}}\right)^\sigma, \tag{2.46}$$

and

$$P_t^{V_j} = \left(\sum_i \nu_{ij}^{\sigma_{V_j}} p_{it}^{1-\sigma}\right)^{1/(1-\sigma)} \quad \omega_{it}^{V_j} = \nu_{ij}^\sigma \left(\frac{P_t^{V_j}}{p_{it}}\right)^\sigma, \tag{2.47}$$

where ω_{it}^C, ω_{it}^I, and $\omega_{it}^{V_j}$ represent optimal shares of respective budgets $P_t^C C_t$, $P_t^I I_t$, and $P_t^{V_j}V_jt$ and where $\sigma = \frac{1}{1-\rho}$. We can now solve for all steady-state variables and deduce values of NX_i^* so that the system of equations 3.13 is satisfied.

Derivation of the consumption price index:

Let λ_t be the lagrange multiplier. The first order condition with respect to C_{kt} $\forall k = m, x, n$ is:

$$[C_t - G(L_{mt}, L_{xt}, L_{nt})]^{(-\gamma)} \left(\sum_{i=m,x,n} \zeta_i C_{it}^\rho\right)^{1/\rho - 1} \gamma_k c_{kt}^{\rho-1} = \lambda_t p_{kt} \tag{2.48}$$

If I let:

$$\xi_t = \lambda_t [C_t - G(L_{mt}, L_{xt}, L_{nt})]^{\gamma}$$

then, I obtain same conditions as those of the standard static optimzation program of the consumer with a CES utility function. We have:

$$\left(\sum_i \zeta_i C_{it}^{\rho}\right)^{1/\rho - 1} \zeta_k c_{kt}^{\rho-1} = \xi_t p_{kt} \tag{2.49}$$

Multiplying this condition by c_{kt} and summing over k gives:

$$\left(\sum_{i=m,x,n} \zeta_i C_{it}^{\rho}\right)^{1/\rho - 1} \sum_{k=m,x,n} \zeta_k c_{kt}^{\rho} = \xi_t \sum_{k=m,x,n} p_{kt} c_{kt}$$

which means:

$$C_t = \xi_t P_t^C C_t$$

or,

$$\frac{1}{\xi_t} = P_t^C$$

We thus need to solve equation (3.15) for ξ_t. We can rewrite this equation as:

$$c_{kt}^{\rho-1} = \frac{1}{\zeta_k} \xi_t p_{kt} (\sum_i \zeta_i C_{it}^{\rho})^{1-1/\rho}$$

We then raise each side to the power $\frac{\rho}{\rho-1}$ and multiply by ζ_k to obtain:

$$\zeta_k c_{kt}^{\rho} = \xi_t^{\frac{\rho}{\rho-1}} \zeta_k^{\frac{-1}{\rho-1}} p_{kt}^{\frac{\rho}{\rho-1}} (\sum_i \zeta_i C_{it}^{\rho})$$

Summing now over k gives the consumption price index:

$$P_t^C = \left(\sum_i \zeta_i^{\frac{1}{1-\rho}} P_{it}^{\frac{-\rho}{1-\rho}}\right)^{\frac{\rho-1}{\rho}}$$

A5. The role of the exchange rate regime

Responses to terms-of-trade shocks should differ according to the exchange rate regime of a country. Precisely, under a flexible exchange regime, external shocks should be damped through the equilibrium adjustment mechanism. In other words, the volatility of macro variables in response to external shocks should be attenuated. Figue 2.10 illustrates this phenomenon. Countries with a fixed exchange rate tend to experience large fluctuations around the equilibrium with a more persisten impact.

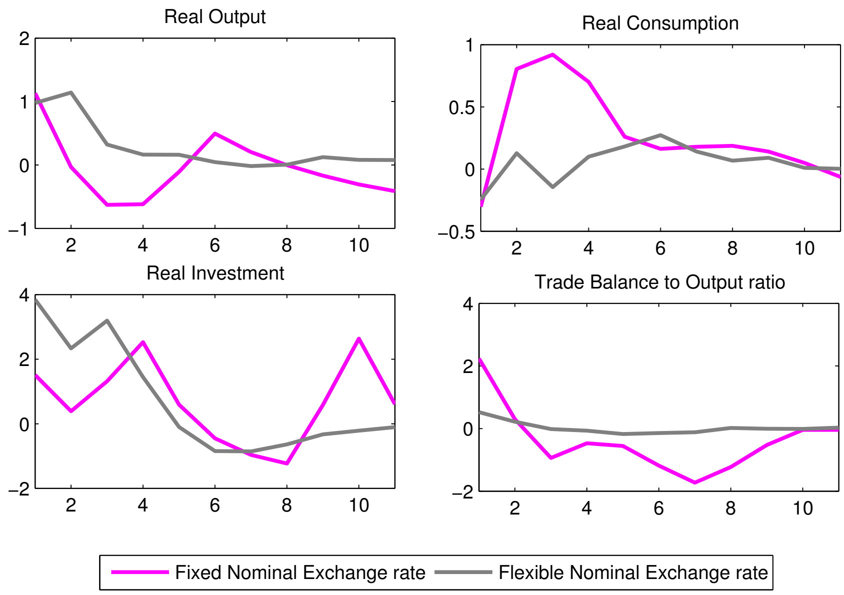
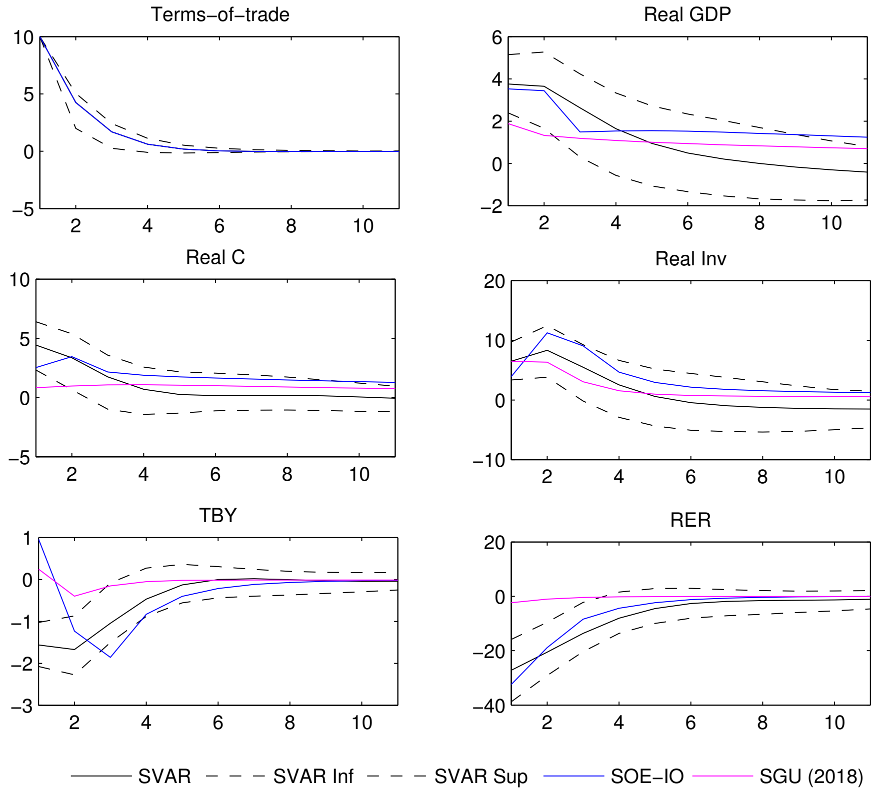


FIGURE 2.10: SVAR Impulse responses : Role of the exchange rate regime

Note: Impulse responses are represented as point-by-point medians across countries (which are classified according o their respective exchange rate regime). Fixed exchange rate countries over the period are Argentina, Malaysia and Thailand. Impulse responses are generated by a 10% terms-of-trgade shock.

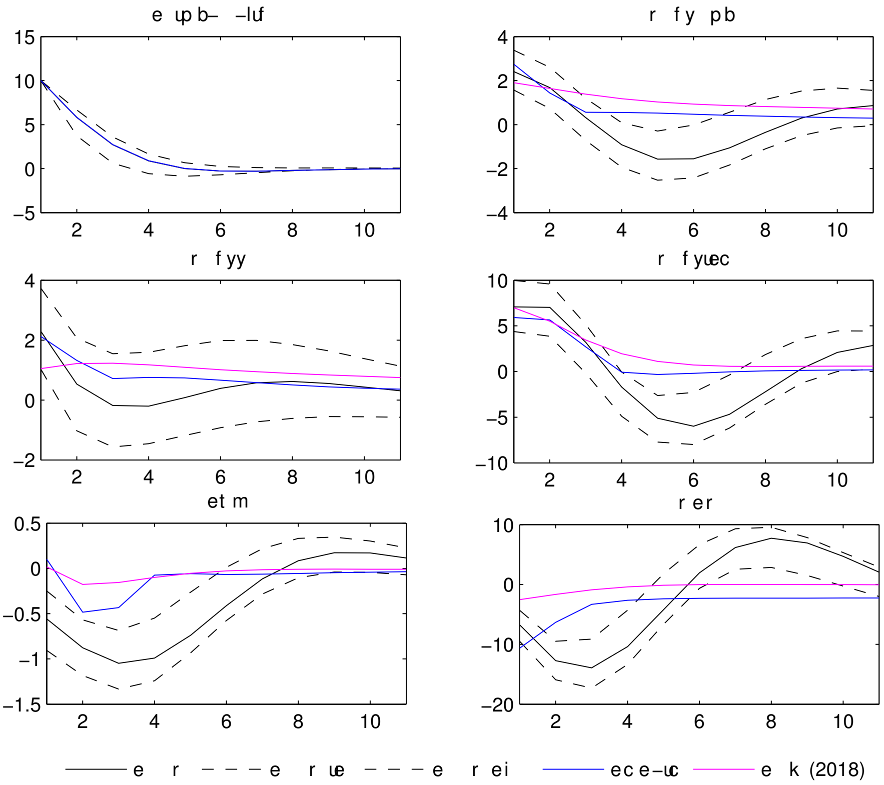
A7. Country-by-country impulse responses

FIGURE 2.11: Impulse Responses of the Models : Argentina



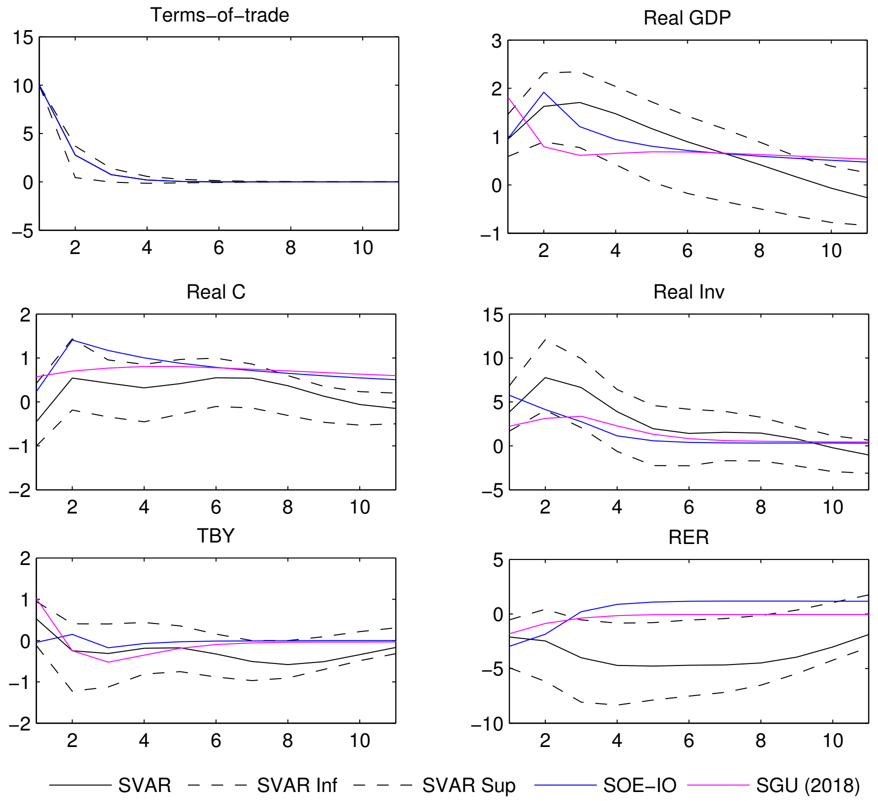
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.12: Impulse Responses of the Models : Brazil



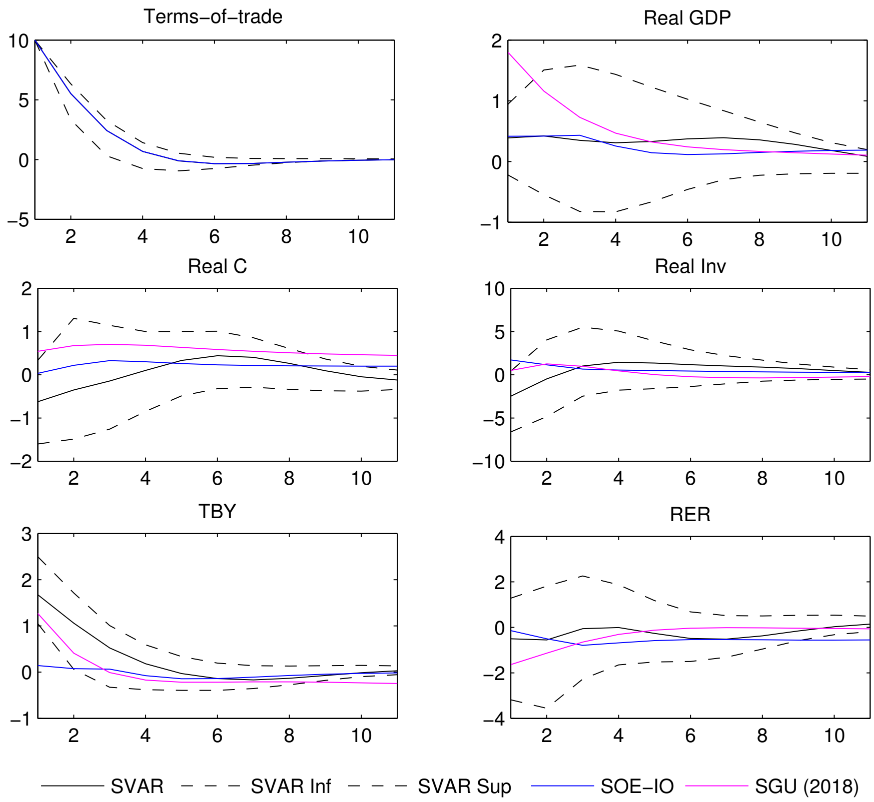
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.13: Impulse Responses of the Models : Colombia



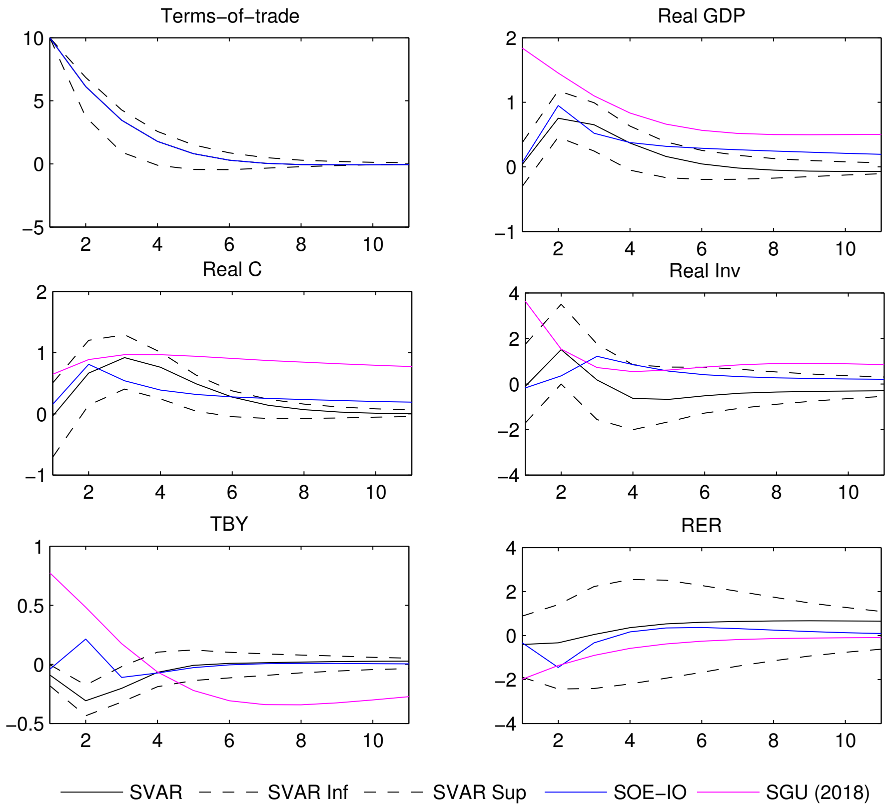
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.14: Impulse Responses of the Models : Costa Rica



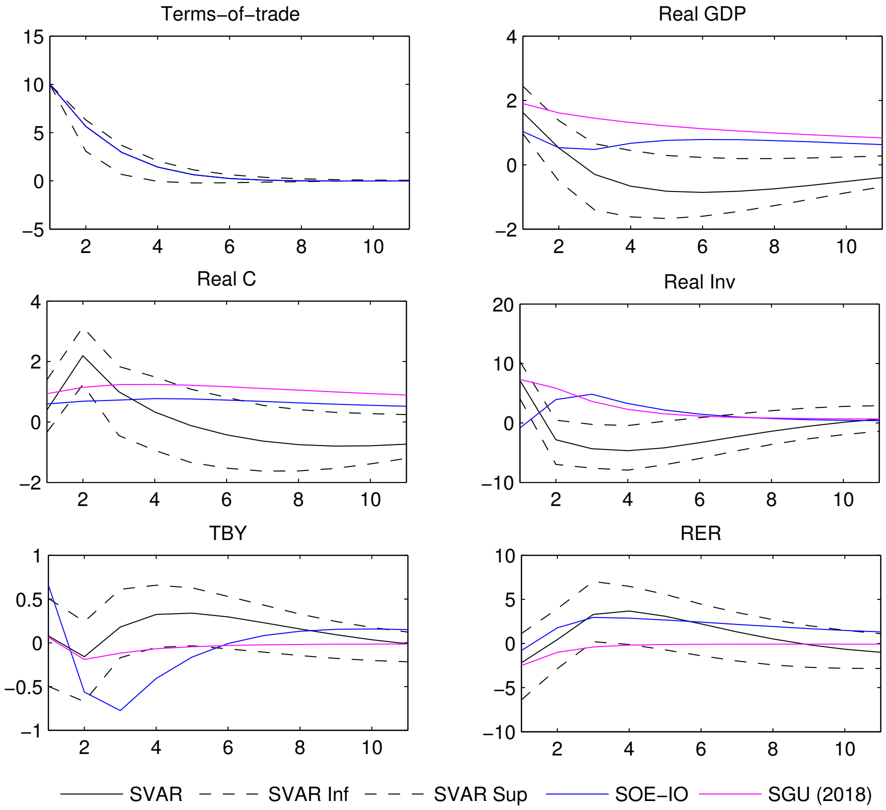
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.15: Impulse Responses of the Models : India



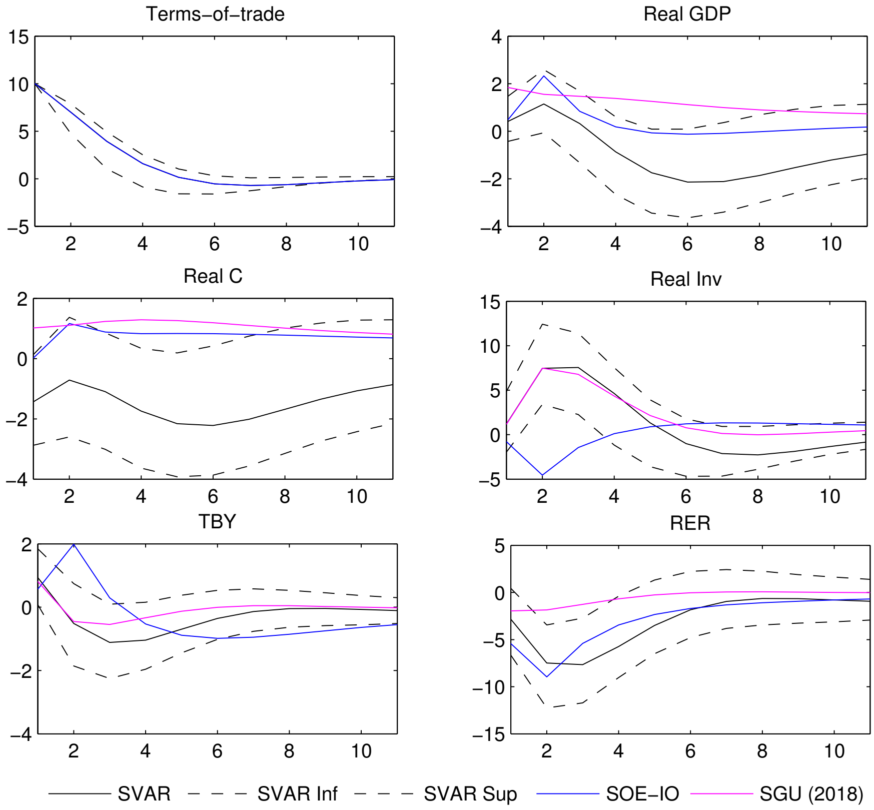
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.16: Impulse Responses of the Models : Indonesia



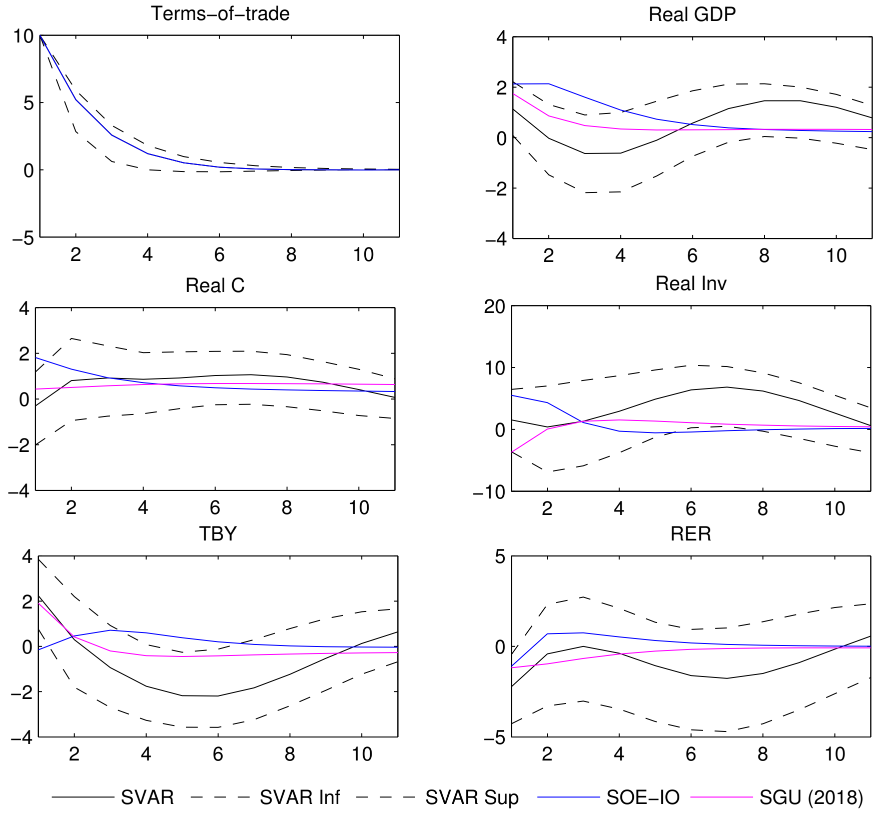
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.17: Impulse Responses of the Models : South Korea



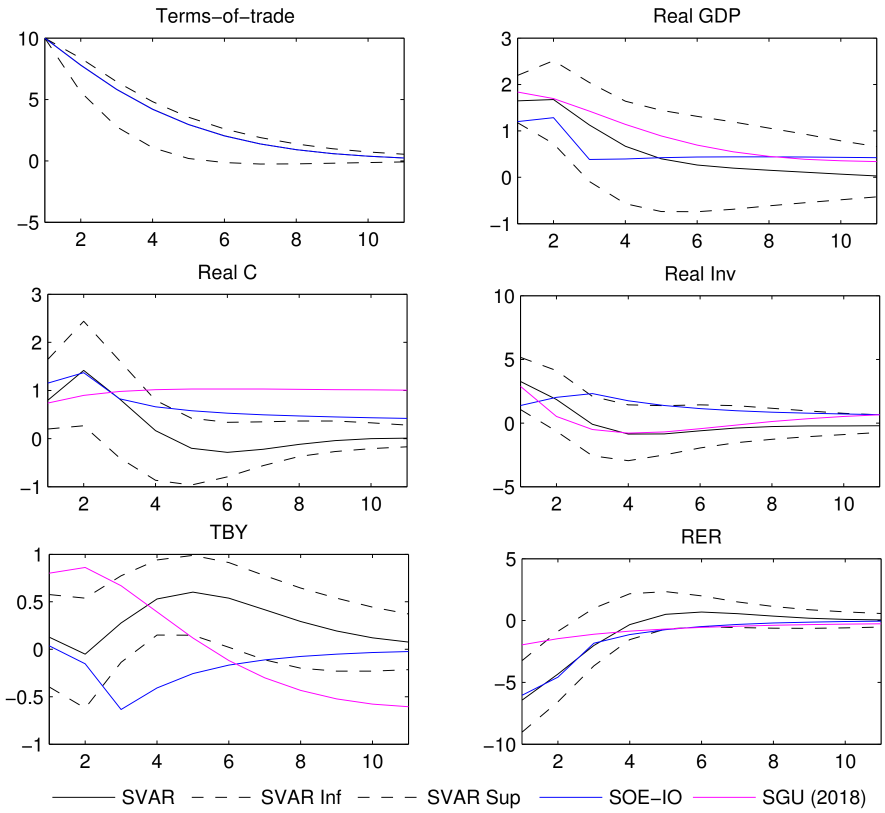
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.18: Impulse Responses of the Models : Malaysia



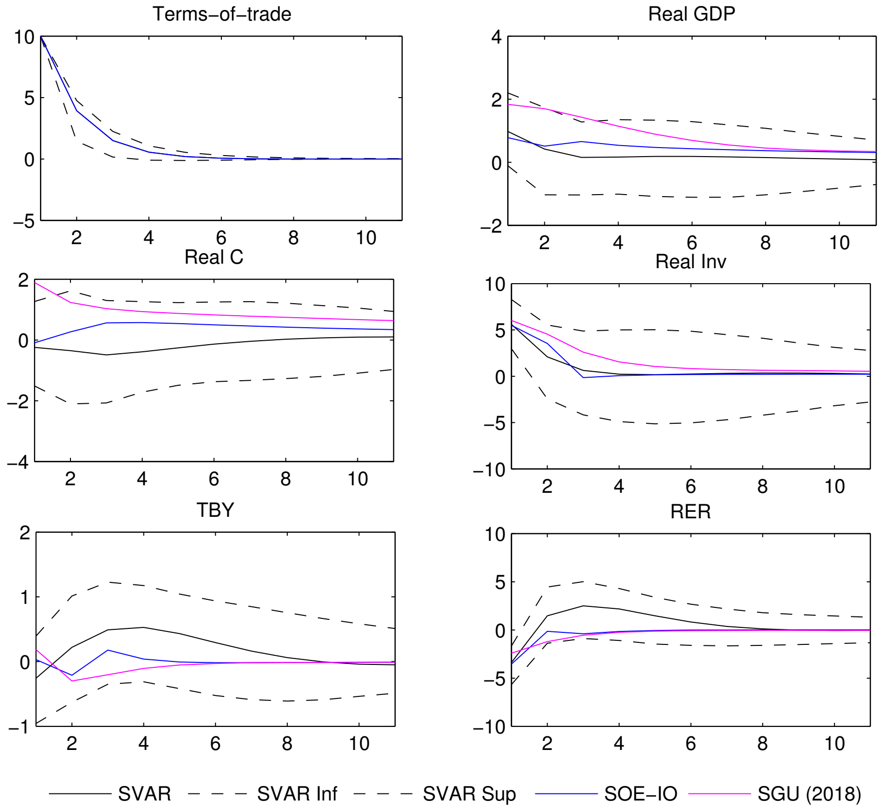
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.19: Impulse Responses of the Models : Mexico



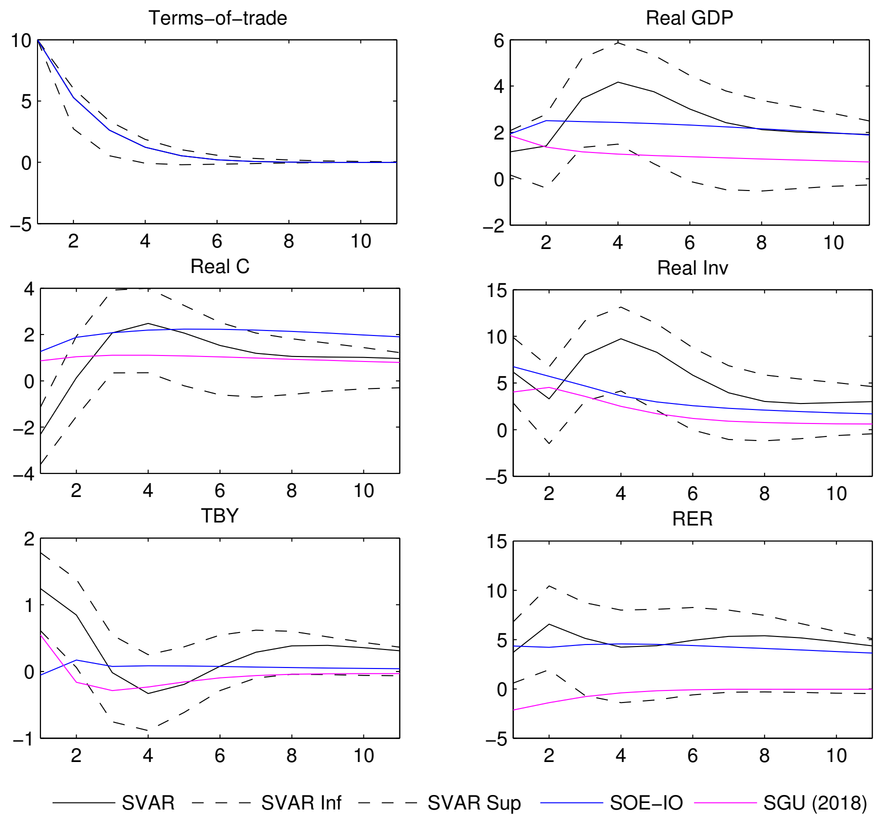
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.20: Impulse Responses of the Models : Morocco



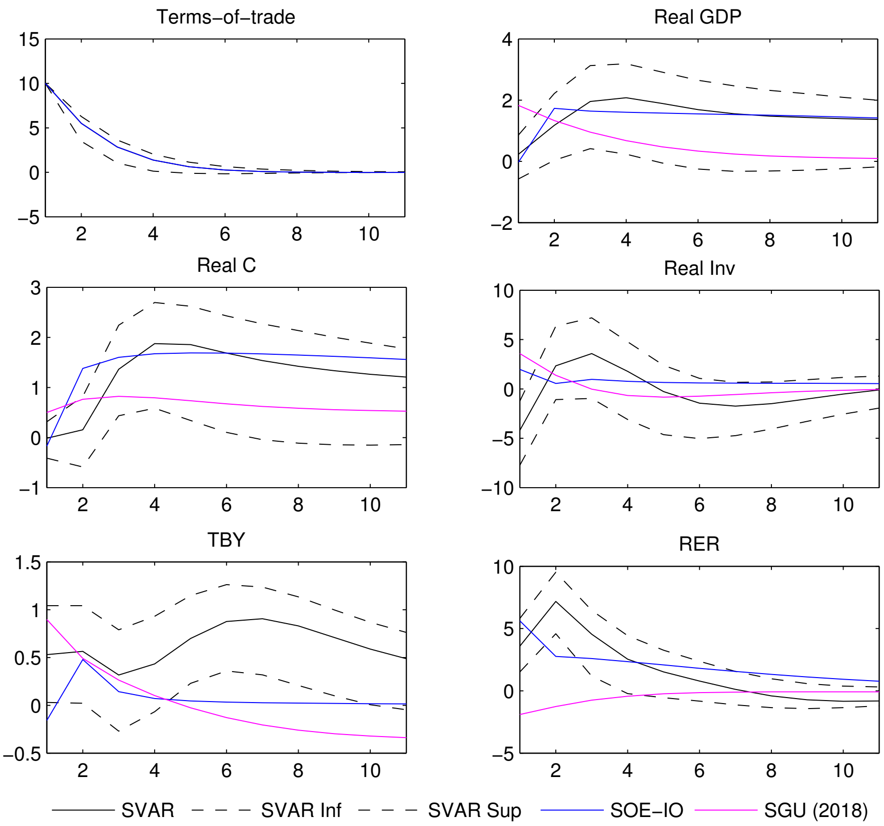
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.21: Impulse Responses of the Models : Peru



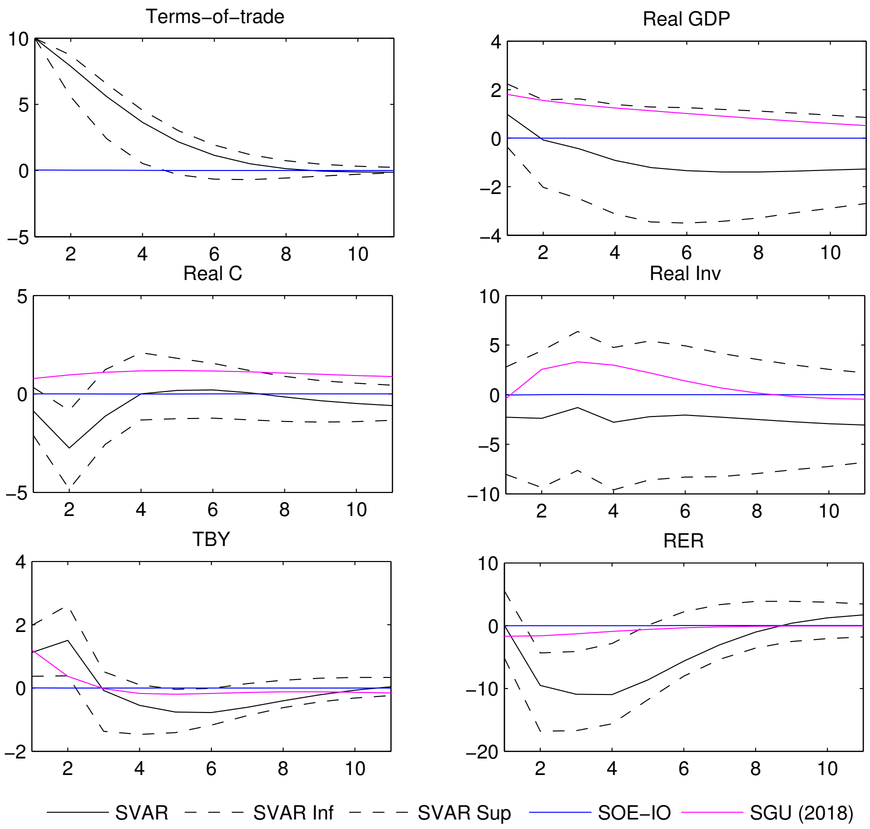
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.22: Impulse Responses of the Models : The Philippines



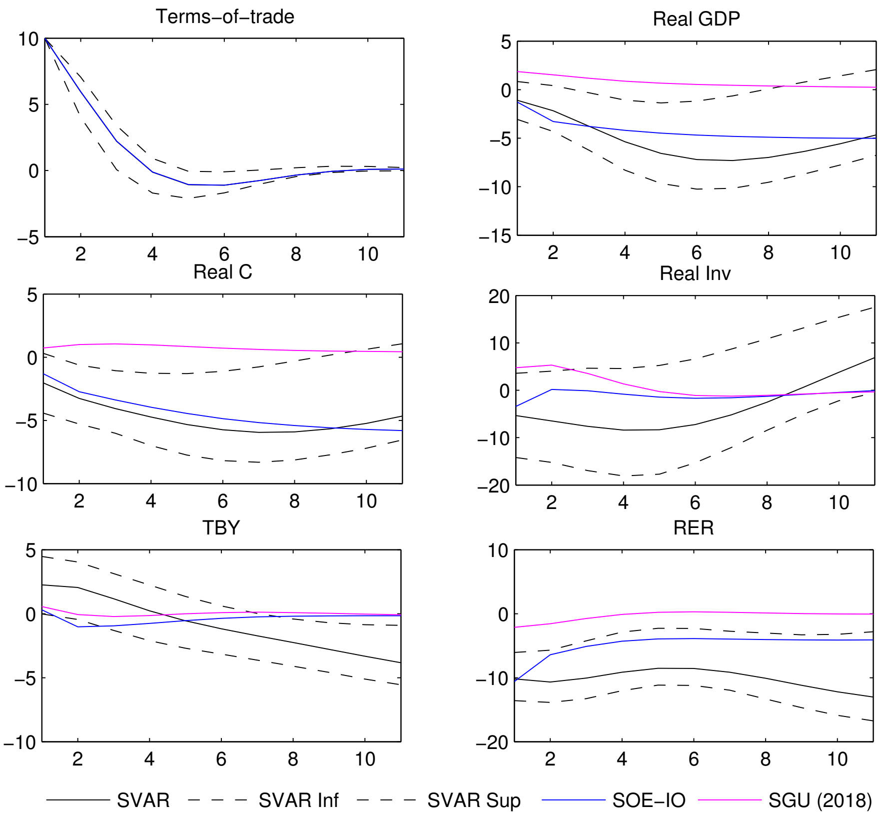
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.23: Impulse Responses of the Models : South Africa



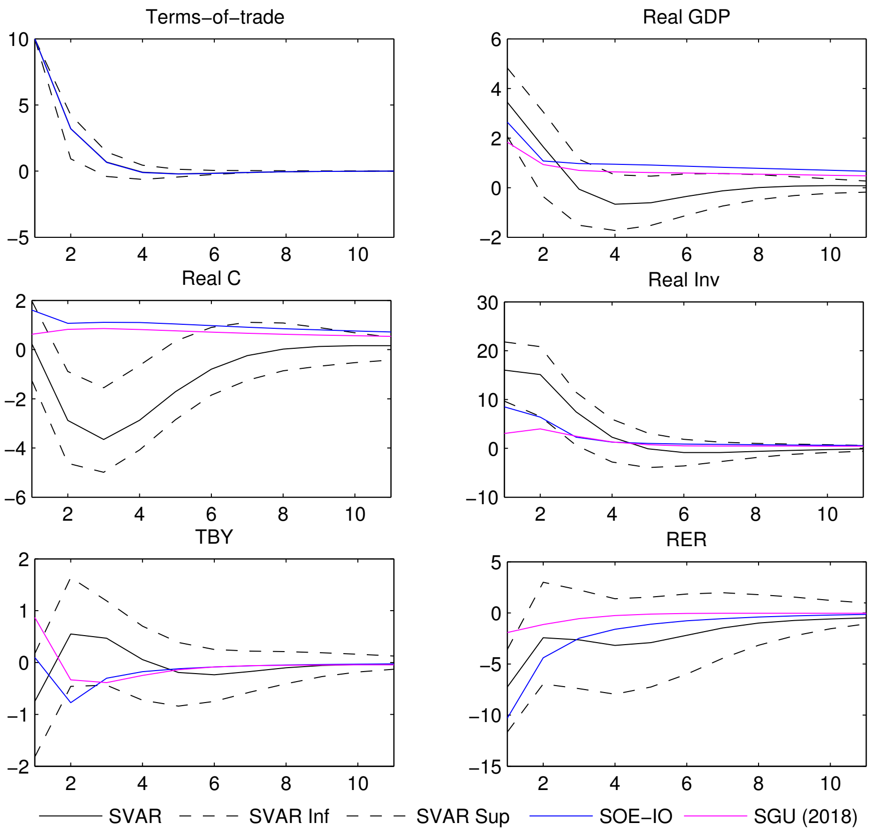
Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.24: Impulse Responses of the Models : Thailand



Note: Dashed lines correspond to the 66% confidence band.

FIGURE 2.25: Impulse Responses of the Models : Turkey



Note: Dashed lines correspond to the 66% confidence band.

3 Terms of Trade or Multiple World Prices ? A Theoretical Analysis of Business Cycles

In a recent empirical SVAR study, Fernandez, Schmitt-Grohe and Uribe (2017) show that world shocks explain a large fraction of business cycles of a domestic economy when mediated by multiple world commodity prices (33%), as agriculture, fuel and metal prices. They conclude therefore that models assuming a single world price measure as a shock transmitter (i.e., terms-of-trade) under-estimate the effects of world shocks (with a result of 10%). We challenge this conclusion and show through a theoretical DSGE model estimated on same data, that a multiple commodity price specification leads to the same result as the one obtained with terms-of-trade. We also show through a simulation exercise that agregating sectors and prices do not imply a lower impact of price shocks in comparison with the disagregated configuration; hence, if empirical predictions diverge, then there might be a financial amplifying mechanism that apply for shocks to commodity prices but not for shocks to terms-of-trade.

3.1 Introduction

Emerging countries are confronted with political instability, financial frictions and both internal and external frequent shocks causing large economic fluctuations. If economists accord on the well-documented empirical facts, they diverge however on the measure of the contribution of each kind of disturbances to fluctuations of developing countries, and even sometimes, on the way to measure disturbances themselves. The recent literature studying the role of external shocks in business cycles of emerging economies, assigns for instance a major role to world shocks when mediated by multiple commodity prices, and a minor role when mediated by a single price measure such as terms-of-trade. The debate has resurfaced with Schmitt-Grohe and Uribe (2018) who show through both an empirical SVAR study and a theoretical DSGE model, that the conventionnal wisdom of an important role assigned to terms-of-trade shocks is actually contradicted. Specifically, they find that on average, terms-of-trade shocks explain a small fraction of movements in domestic output of around 10%. This estimation appears indeed quite far from the 30% in our minds since Mendoza (1995) and Kose (2002). In another empirical SVAR study, Fernandez, Schmitt-Grohe and Uribe (2017) show that world shocks transmitted by multiple commodity prices (for instance agriculture, fuel and metals) contribute to a large part of business fluctuations in many countries (33% on average and even 68% for the case of Argentina). They confirm therefore results of many other studies in the literature and conclude in consequence that models assuming a single world price measure as a shock transmitter, under-estimate the effects of world shocks.

In this chapter, we propose to analyze the role of world commodity prices in explaining business cycles of a domestic economy through the lens of a DSGE model. Our goal is to see whether empirical results are confirmed and if so, to the detriment of which of the other shocks commonly studied in this literature, for instance, the permanent and temporary productivity shocks, the interest-premium shock and the preference shock. I rely on the model of Garcia-Cicco et al (2010) of a small-open economy (SOE) and extend it to four sectors along the structure of input-output (IO) data. The four sectors refer to the three commodity ones considered by Fernandez et al. (2017) and to a fourth one which represents the rest-of-the domestic economy. The model (which we will refer to as the SOE-IO model) is then calibrated and estimated on annual data of Argentina from 1960 to 2011. Specifically, I use the same data on commodity prices as Fernandez et al. (2017), and same data on macroeconomic aggregates as Schmitt-Grohe and Uribe (2018) in their study of the role of terms-of-trade shocks.

Results challenge the conclusion of Fernandez et al. (2017). The SOE-IO model does not confirm the important share of variance of domestic output explained by multiple world commodity prices. The estimated share of variance appears indeed extremely close to the one obtained by Schmitt-Grohe and Uribe (2018) under the single price specification of terms-of-trade (12% versus 13%.) In other words, the impact of external shocks captured by multiple prices of traded goods would actually be equivalent to the impact measured using a single representative price index agregated over the multiple traded goods. I explain this result through a simulation exercise and show that fluctuations of output caused by world shocks in a theoretical DSGE framework do not depend only on the number of prices used as transmitters, but also on the level of aggregation of sectors and more precisely, on the relative size of the domestic supply and demand for the representative good.

I conclude in consequence that the disconnect between empirircal and theoretical predictions might have two potential explanations. On the empirical side, it might be that the SVAR model omits relevant information on the structure of an economy, so that it tends to over-predict the volatility of output explained by commodity price shocks on world markets (note for example that 10% of the GDP of Argentina is predicted to explain 68% of its volatility). On the theoretical side, it could also be that the SOE model omits an amplifying financial mechanism regarding the impact of commodity price shocks. Many contributions in the literature explain indeed that financial actors relate price variations of popular commodities of countries to their respective level of risk.

The remaining of the paper is organized as follows. Section 2 presents an extension of the model of Garcia-Cicco et al (2010) (GPU) to multiple sectors based on the structure of input-output tables. Section 3 presents the calibration and estimation strategy of the model. Section 4 analyzes results and section 5 concludes.

3.2 Model

3.2.1 The supply side

The proposed theoretical DSGE model extends the one of Garcia-Cicco et al. (2010) (GPU) to four sectors indexed by $j = a, f, m, d$, where a, f, and m refer respectively to the agriculture, fuel and metal commodity sector, and d, to the aggregate rest-of-the domestic economy. Each sector is composed of a large number of identical firms which employ labour and the goods produced as fixed and intermediate capital goods; the multi-sector version proposed replicates indeed the structure of input-output tables. The technology in each sector exhibits constant returns to scale (CRS) and is defined as :

$$Q_{jt} = B_{jt}[K_j(X_t)^{\alpha}(A_t L_{jt})^{1-\alpha}]^{1-\theta} V_j(X_t)^{\theta} \tag{3.1}$$

where Q_{jt}, $V_j(X_t)$, $K_j(X_t)$, and L_{jt} denote respectively gross production, aggregate intermediate consumption, aggregate fixed capital, and labor employed by sector j at time t. The level of aggregate capital and intermediate consumption in each sector is expressed as a function of quantities of goods produced in the economy $X_t = (X_{at}, X_{ft}, X_{mt}, X_{dt})$. We let B_{jt} denote a total productivity factor that follows an AR(1) process supposed to be the same for all sectors :

$$\log B_{t+1} = \rho_a . \log B_t + \epsilon^B_{t+1}, \quad \epsilon^B_t \sim N(0, \sigma^2_B).$$

We also let A_t capture a growth trend supposed affected by shocks over time due for example to policy regime switches, as explained for example by Aguiar and Gopinath (2007). Precisely, we assume a common trend shock in each sector which follows a non-stationary process with:

$$g_t \equiv \frac{A_t}{A_{t-1}},$$

where g_t defines the growth rate of A_t and follows an AR(1) process of the form:

$$\log \frac{g_{t+1}}{g} = \rho_g \log \frac{g_t}{g} + \epsilon^g_{t+1}; \quad \epsilon^g_t \sim N(0, \sigma^2_g).$$

The parameter g denotes a deterministic long run mean growth rate.[1] Total profit is expressed as:

$$\Pi_{jt} = p_{jt} Q_{jt} - u_{jt} K_j(X_t) - w_{jt} L_{jt} - P^{V_j}_t V_j(X_t)$$

where u_{jt} denotes the capital remuneration rate paid by sector j, $P^{V_j}_t$ is the price index of the intermediate good basket used by sector j, w_{jt} is the wage rate paid, and p_{jt} denotes the price of good j at time t. The first-order conditions are given by:

$$\partial p_{jt} Q_{jt} / \partial K_j(X_t) = u_{jt} \tag{3.2}$$

[1]Equation (3.1) is actually standard in general equilibrium models that incorporate intermediate capital in the production technology; e.g. Jones (2011) or Moro (2012). We simply extend it with $K_j(X)$ and $V_j(X)$ to account for the multiple input goods as described by input-output tables.

$$\partial p_{jt} Q_{jt} / \partial L_{jt} = w_{jt} \tag{3.3}$$

$$\partial p_{jt} Q_{jt} / \partial V_j(X_t) = P_t^{V_j} \tag{3.4}$$

3.2.2 Households

A representative household of the domestic country maximizes a lifetime utility function that depends on consumption of a combination of goods and hours worked in each sector. The lifetime utility function is given by:

$$E_0 \sum_{t=0}^{\infty} \nu_t \beta^t U(C(X_t), L_{at}, L_{ft}, L_{mt}, L_{dt}) \tag{3.5}$$

We recall the period utility function assumed by Schmitt-Grohe and Uribe (2018) (SGU), which is a Greenwood, Herkowitz and Hoffman (1988) utility function combining consumption and labor in a quasilinear form, with the particularity of dissociating labor by sector :

$$U(C(X_t), L_{at}, L_{ft}, L_{mt}, L_{dt}) = \frac{[C(X_t) - G(L_{at}, L_{ft}, L_{mt}, L_{dt})]^{(1-\sigma)} - 1}{1-\sigma}$$

where

$$G(L_{at}, L_{ft}, L_{mt}, L_{dt}) = \frac{L_{at}^{\tau_a}}{\tau_a} + \frac{L_{ft}^{\tau_f}}{\tau_f} + \frac{L_{mt}^{\tau_m}}{\tau_m} + \frac{L_{dt}^{\tau_d}}{\tau_d}$$

with τ_j being strictly positive preference parameters $\forall j = m, x, n$ that restrict labor flows across sectors in case of different wgaes.[2] We let $C(X_t)$ denote aggregate consumption and, more precisely, a composite consumption utility index defined by the classical Armington (1969) aggregator:

$$C(X_t) = (\zeta_a X_{at}^{\gamma} + \zeta_f X_{ft}^{\gamma} + \zeta_m X_{mt}^{\gamma} + \zeta_d X_{dt}^{\gamma})^{1/\gamma}$$

[2]Note als that $\frac{1}{\tau_j - 1}$, represents the labor elasticity with respect to real wage

where ζ_j denote relative preference parameters for good j. The model assumes a preference shock process ν_t which follows an AR(1) process given by:

$$\log \nu_{t+1} = \rho_\nu . \log \nu_t + \epsilon^\nu_{t+1}, \quad \epsilon^\nu_t \sim N(0, \sigma^2_\nu).$$

To simplify notations, we now let $C_t = C(X_t)$, $K_{jt} = K_j(X_t)$, and $V_{jt} = V_j(X_t)$. We also let real investment of sector j be defined as $I_{jt} = I_j(X_t)$. The sequential budget constraint faced by the household when maximizing this objective function is defined as:

$$P^C_t C_t + \sum_j \left(P^{I_j}_t I_{jt} + \frac{\phi}{2} \left(\frac{K_{jt+1}}{K_{jt}} - g \right)^2 K_{jt} \right) = \frac{D_{t+1}}{1+r_t} - D_t + \sum_j [u_{jt} K_{jt} + w_{jt} L_{jt}],$$

where P^C_t denotes the consumption price index, $P^{I_j}_t$ is the investment price index associated to the aggregate investment in fixed capital I_{jt} in sector j (expressed in real terms). The parameters ϕ_j refer to a capital adjustment cost in each sector. It is assumed indeed that final goods invested are not equally transformed into productive capital. The quantity D_t represents the amount of foreign debt due at time t, and r_t denotes the debt interest rate from period t to $t+1$.

We let the laws of motion of capital be defined as [3]:

$$K_{jt+1} = (1-\delta) K_{jt} + I_{jt} \tag{3.6}$$

The resolution of the household's program consists in choosing C_t, L_{at}, L_{ft}, L_{mt}, L_{dt}, D_{t+1}, K_{at+1}, K_{ft+1}, K_{mt+1}, and K_{dt+1} to maximize the objective function (3.5) subject to the sequential budget constraint (detailed resolution is shown in the Appendix).

[3]We suppose same functions for the aggregate measure of capital and investment. The assumption of an aggregate investment good can also be found in an IMF working paper of Fernandez, Gonzales and Rodriguez (2015).

3.2.3 Equilibrium of markets

We show in appendix that the household program can be mathematically separated into two steps which are linked by the aggregate price indexes. In the first (inter-temporal) one presented in the previous section, the household plans the consumption budgets under perfect information (hence, taking into account the evolution of prices). In a second (intra-temporal) step, households spend the planned consumption budget $P_t^C C(X_t)$ on the different sector goods. In other words, we get indentical results if we solve for optimal levels of consumption X_{at}^C, X_{ft}^C, X_{mt}^C, X_{dt}^C in the previous inter-temporal program, or if we proceed in two steps by solving first for the optimal level $P_t^C C(X_t)$ and next, for the optimal levels of each good within a 'standard' intra-temporal consumer program. In any case indeed, if $C(X_t)$ is maximized then optimal shares of the planned consumption budget are given by :

$$\omega_{it}^C = \zeta_i^{\sigma_C} \left(\frac{P_t^C}{p_{it}} \right)^{\sigma_C} \qquad \forall i = a, f, m, d, \tag{3.7}$$

and the corresponding price index is expressed as:

$$P_t^C = \left(\sum_i \zeta_i^{\sigma_C} p_{it}^{1-\sigma_C} \right)^{1/(1-\sigma_C)} \tag{3.8}$$

where σ_C denotes the consumption elasticity of substitution.

By analogy with consumption, assuming a CES aggregator to quantify investment of households in sector j, implies optimal shares of the planned investment budget $P_t^{I_j} I_{jt}$ that are given by :

$$\omega_{it}^{I_j} = \kappa_{ij}^{\sigma_I} \left(\frac{P_t^{I_j}}{p_{it}} \right)^{\sigma_I} \qquad \forall i, j = a, f, m, d, \tag{3.9}$$

with a corresponding price index given by:

$$P_t^{I_j} = \left(\sum_i \kappa_{ij}^{\sigma_I} p_{it}^{1-\sigma_I} \right)^{1/(1-\sigma_I)}, \tag{3.10}$$

where κ_{ij} denotes a technical parameter and σ_I the degree of elasticity of substitution between investment goods. We will assume from now that shares of investment budgets are identical across sectors, that is, $\omega_{it}^{I_j} = \omega_{it}^{I}$, which means $\kappa_{ij} = \kappa_i$ and $P_t^{I_j} = P_t^I \forall j = a, f, m, d$ (given the lack of information in input-output data[4]).

We finally assume in a same way a CES aggregator for intermediate consumption of sector j and we define omptimal shares of the corresponding budget as:

$$\omega_{it}^{V_j} = \nu_{ij}^{\sigma_V} \left(\frac{P_t^{V_j}}{p_{it}} \right)^{\sigma_V} \qquad \forall i, j = a, f, m, d, \tag{3.11}$$

and the price index as:

$$P_t^{V_j} = \left(\sum_i \nu_{ij}^{\sigma_V} p_{it}^{1-\sigma_V} \right)^{1/(1-\sigma_V)}, \tag{3.12}$$

where ν_{ij} denotes a technical parameter regarding the use of intermediate goods.

Equilibrium of commodity markets implies :

$$\omega_{it}^C P_t^C C_t + \sum_j \omega_{it}^{I_j} P_t^{I_j} I_{jt} + \sum_j \omega_{it}^{V_j} P_t^{V_j} V_{jt} + NX_{it} = p_{it} Q_{it} \tag{3.13}$$

where NX_{it} denotes net exports of good i at time t. Summing equation (3.7) over each good i, and combining the result with the budget constraint, leads to:

$$\frac{D_{t+1}}{1+r_t} - D_t = \sum_j \frac{\phi}{2} \left(\frac{K_{jt+1}}{K_{jt}} - g \right)^2 K_{jt} - \sum_i NX_{it} \tag{3.14}$$

[4]Gross fixed capital formation is indeed aggregated over sectors.

which means that indebtment finances net imports and capital adjustment costs. The trade balance is given by:

$$TB_t = -(\frac{D_{t+1}}{1+r_t} - D_t) \tag{3.15}$$

Definition

Assuming an economy of J sectors that are indexed by j and that each produce a specific good $i \in J$, a competitive equilibrium is a set of $J \times 16 + 6$ processes K_{jt+1}, V_{jt}, L_{jt}, λ_t, Q_{jt}, C_{jt}, ω^C_{it}, $\omega^{I_j}_{it}$, $\omega^{V_j}_{it}$, w_{jt}, p_{jt}, P^C_t, $P^{I_j}_t$, $P^{V_j}_t$, D_{t+1}, r_t, s_t, TB_t, and NX_{jt}, satisfying equations (3.1) to (3.15), given the initial conditions K_{j0}, V_{j0}, and D_{-1}.

3.2.4 Price and Interest Premium shocks

The context of a small open economy means that the country has no possibility to influence world prices or the world interest rate. The economy is supposed to take world commodity prices as given and to adjust to shocks that occur on world markets. To analyze the macroeconomic dynamics following shocks on multiple world prices, we propose to recall the ('foreign bloc' of the) VAR structure from Fernandez et al. (FSGU), and to implement it within the theroetical model. For instance,

$$\widehat{p}_t = A\widehat{p}_{t-1} + \epsilon^p_t, \tag{3.16}$$

where $\widehat{p}_t$ denotes a 3×1 vector of commodity prices p_{at}, p_{ft}, p_{mt} expressed in log terms and detrended using the HP filter (with a smoothing parameter of 100), A is the matrix of AR coefficients defined as a_{ij}, and ϵ^p_t, an i.i.d. mean-zero vector of innovation terms ϵ^a_t, ϵ^f_t, and ϵ^m_t, with variance-covariance matrix Σ_ϵ. Rather than simply recalling OLS estimates of A and Σ_ϵ, we propose to include the shock process to the overall Bayesian estimation of the model.

Assuming perfectly divisible goods, we let units of quantities be such that $p_a^* = p_f^* = p_m^* = p_d = 1 \; \forall t$ (where p_j^* denote steady-state levels), and let log deviations from steady-states $\log(p_{at})$, $\log(p_{ft})$, and $\log(p_{mt})$ correspond to $\widehat{p_{at}}$, $\widehat{p_{ft}}$, and $\widehat{p_{mt}}$.

Two versions of the model will be estimated next. In the first one, the price index of the domestic sector p_d is considered fixed. In a second version of the model, this price is supposed to respond to variations of other prices according to the following rule:

$$\log(p_{dt}) = a_{da}\log(p_{at-1}) + a_{df}\log(p_{ft-1}) + a_{dm}\log(p_{mt-1}) \tag{3.17}$$

The domestic interest rate is given by:

$$r_t = r^* + s_t + \psi(e^{\tilde{D}_t - D^*} - 1) \tag{3.18}$$

where r^* denotes the world interest rate, ψ, a debt premium sensitivity parameter and s_t, a country specific interest spread defined by

$$s_t = s^* + exp(\mu_t - 1).$$

We suppose that μ_t is a shock that follows an AR(1) process:

$$\log(\mu_t) = \rho_\mu \log(\mu_{t-1}) + \epsilon_t^\mu, \tag{3.19}$$

where ϵ_t^μ denotes an innovation term with mean one and variance σ_μ^2. The variable $\tilde{D}_t$ represents the aggregate level of external debt per capita that households take as given.

3.2.5 Observables

We calibrate parameters that influence the steady-state equilibrium and estimate the remaining ones which matter on the dynamics. To calibrate the model, we aggregate OECD input-output data for the year 2000 over the four sectors in consideration. We then estimate the model using annual data of commodity prices, output, consumption, investment and the interest spread. We recall data on commodity prices from FSGU, which cover the period 1960-2011, and the remaining data from SGU to work with a larger sample that covers the same period.

We define the theoretical counterpart of GDP as:

$$Y = \sum_i (p_{jt}Q_{jt} - P_t^{V_j}V_{jt}),$$

and apply the same the same deflation rule as in the data. Indeed, the data source applies a Paasche GDP deflator to macro aggregates, defined as the ratio of current price to constant price GDP. In our theoretical context, this deflator can be defined as:

$$P_t^0 = \frac{\sum_i (p_{jt}Q_{jt} - P_t^{V_j}V_{jt})}{\sum_i (p_j^* Q_{jt} - P^{V_j*}V_{jt})}$$

where P^{V_j*} denotes the steady-state price indexes. Real GDP is therefore given by:

$$\hat{Y} = \sum_i (p_j^* Q_{jt} - P^{V_j*}V_{jt})$$

The theoretical counterparts of real consumption and investment are given by:

$$\hat{C} = \frac{P_t^C C_t}{P_t^0}$$

The theoretical counterpart of real investment is given by:

$$\hat{I} = \sum_j \frac{P_t^{I_j} I_{jt}}{P_t^0}$$

3.3 Calibration and Estimation: Argentina 1960-2010

3.3.1 Calibration of the SOE-IO model

The model with four sectors is medium scale in size but can be calibrated on real data given its structure is directly in line with input-output tables. There are 83 variables (ignoring deflated and log transfomed ones) and 77 parameters. Those which influence the steady-state equilibrium are calibrated, and the remaining ones which influence the dynamics, for instance, ψ, ϕ_j, and all shock process parameters, are estimated. Table 3.1 summarizes the calibration and estimation of all parameters. The 55 parameters to calibrate are α_j, B_j^*, θ, β, δ, σ, p_a^*, p_f^*, p_m^*, p_d^*, τ_j, κ_i, ν_{ij}, ζ_i, σ_C, σ_I, σ_V, $(r^* + s^*)$, and D^*, $\forall i, j \in J$. Some of them are asigned values recalled from the literature. For instance $\sigma = 2$ and $\tau_j = 1.455$ so as to ensure an equilibrium labor elasticity of 2.1 as in Schmitt-Grohe and Uribe (2018). We let $\alpha_j = 0.32$, $r^* = 0.07$, $s^* = 0.04$, $\beta = \frac{1}{1+r^*+s^*} = 0.9$, $\delta = 0.126$, $D^* = 0.1$, and $\theta_j = 0.5$. Under the assumption of perfectly divisible goods, units of output in each sector can always be defined so as that $P_{a*} = P_{f*} = P_{m*} = 1$. The relative values of B_j are calibrated to match the sizes of sectors and their absolute levels is defined so as to approximate the consumption-output ratio of 85%. The equilibrium growth rate of variables g is supposed equal to 1.01 as estimated by Garcia-Cicco et al. (2010) for Argentina. Input-output parameters κ_i, ν_{ij}, and ζ_i are calibrated to match, respectively, the observed investment budget shares $\omega_{it}^{I_j}$ (supposed as equal for all sectors), the observed intermediate consumption shares of goods used by each sector $\omega_{it}^{V_j}$, and the observed consumption shares of goods defined previously as ω_{it}^{C}. Finally, let degrees of elasticity of substitution between goods σ_C, σ_I, and σ_V are arbitrarily set equal to 2 (however, we will perform robustness checks with different assumptions going from perfect complementarity to perfect substitution).

TABLE 3.1: Calibration and Estimation of parameters

Parameters	Description	Source	Value
σ	CRRA	set	2
g	Equilibrium growth rate	set (Garcia-Cicco et al (2010))	1.01
δ	Depreciation rate	set (Garcia-Cicco et al.)	0.126
$r^* + s^*$	Risk-free interest rate + spread	set (Uribe and Yue (2006))	0.11
β	Time Discounting rate	SGU (2018)	0.9009
α_j	Capital shares (X and M sector)	set	0.32
p_j^*	Final good prices	set	1
D^*	External debt	set (GPU)	0.01
θ_j	Intermediate consumption share	set	0.5
B_j	Total Productivity parameters	calibrated to target $P_jY_j / \sum P_jY_j$	Table 3.14
τ_j	Utility parameters	set as Schmitt-Grohe et al. (2018)	1.455
ζ_i	Preference parameter	calibrated to target ω_{it}^{C}	Table 3.14
κ_i	Technological parameter	calibrated to target $\omega_{it}^{I_j}$	Table 3.14
ν_{ij}	Technological parameter	calibrated to target $\omega_{it}^{V_j}$	Table 3.14
σ_C	Elasticity of substitution	set	2
σ_K	Elasticity of substitution	set	2
σ_V	Elasticity of substitution	set	2

Tables 3.14 is displayed in appendix

3.3.2 Bayesian estimation

We define the set of parameters to estimate as:

$$\Omega = \left[\psi, \phi_j, \rho_g, \rho_B, \sigma_g, \sigma_B, \rho_\mu, \sigma_\mu, \rho_v, \sigma_v, a_{ij}, \sigma_{\epsilon^j}\right],$$

$\forall i, j = a, f, m$. Given a prior $p(\Omega)$, the posterior density of the model parameters, Ω, is given by:

$$p(\Omega|Z^T) = \frac{L(\Omega|Z^T)p(\Omega)}{\int L(\Omega|Z^T)p(\Omega)d\Omega}$$

where $L(\Omega|Z^T)$ is the likelihood conditionnal on observed data $Z^T = (Z_1, ..., Z_T)$, where $Z_t = (Z_{1t}, Z_{2t}, ..., Z_{7t})$ refers to the set of observed variables at time t, with Z_{1t} denoting the growth rate of real output at time t, Z_{2t}, the growth rate of real consumption, Z_{3t}, the growth rate of real investment, Z_{4t}, the trade balance-to-output ratio, Z_{5t}, the HP filtered price index of agriculture, Z_{6t}, the HP filtered price index of fuel, and Z_{7t}, the HP filtered price index of metals.

Posterior statistics are based on a Metropolis-Hasting algorithm of 400,000 replications, from which the first 200,000 draws are discarded. Details are available in appendix with a Brooks and Gelman's convergence diagnostics based on two chains. We also estimate the standard deviations of measurement errors on observable as in GPU and keep the same prior (uniform) distributions for all estimated parameters.

3.4 Results

3.4.1 Multiple world price specification

Before studying the role of world shocks mediated by multiple prices, it is comforting to perform a prior checking of estimation results with no price shocks of the GPU and the SOE-IO model on samples of SGU (from 1960 to 2011) and GPU (1900 to 2005). Results in appendix (Table 3.6) show that estimations converge for the two samples. The SOE-IO model provides estimates close to those obtained with the GPU model on their sample, fitting therefore the data in a same way by assigning a major role to temporary productivity shocks, and giving an explanation of the bulk of consumption volatility relatively to outcome through the preference shock (Table 3.8 in appendix). It also confirms the presence of some financial frictions with a coefficient ψ measured at 3.97 (entering the confidence intervall of GPU). Both models however diverge regarding the sample of SGU. In each case, it is the trend component of the productivity shocks which predominates this time over the transitory one as the main driver of observed fluctuations. The share of variance of output explained by trend shocks is above 80% and the quality of fit of both models remains excellent except the autocorrelation of the trade balance insufficiently captured by a low parameter ψ; e.g., Tables 3.7, 3.8, and 3.9 in appendix. In other words, depeding on which sample is used, the hypothesis of Aguiar and Gopinath (2007) that 'the cycle is the trend' is supported or not. It is not the goal of the paper to investigate this issue. Having 'validated' the proposed SOE-IO model as an extension of the GPU one (for instance by showing that estimation results are similar), we perform the estimation of the set of parameters Ω on SGU data.

Results of the estimation are displayed in Table 3.6. We consider two different ways for world shocks to impact the domestic economy. In the first case (Model 1), producers of the domestic sector do not adjust prices in response to changes in production costs. In the second case (Model 2), we suppose they revise prices along the rule defined previously (3.17). The VAR estimates for both models is displayed in appendix (Table 3.10).

Results of Model (1) in comparison to those of the model with no price shocks (exposed in appendix in Table 3.7), provides values for common parameters that are relatively close. In other words, the introduction of shocks affecting sector prices is not coming with a reduction of the estimated size or persistence of other shocks, and for instance of the interest premium shock. This result sounds indeed in contradiction with a remark from Shousha (2015) according to which models omitting the effects of commodity prices leads to an over-estimation of country spreads. In Model (2), we notice that only fluctuations in metal prices may transmit significantly to domestic prices. However, results do not show a more important role of world shocks when looking at the variance decomposition analysis in Table 3.3. It seems also that

TABLE 3.2: Prior and Posterior Distributions

			Posterior distribution					
	Prior distribution		Model (1)			Model (2)		
Parameter	Min	Max	Median	5%	95%	Median	5%	95%
ρ_g	-0.99	0.99	0.61	0.46	0.79	0.68	0.54	0.82
σ_g	0	0.2	0.02	0.016	0.028	0.023	0.018	0.028
ρ_b	-0.99	0.99	0.6	0.012	0.99	0.16	-0.56	0.99
σ_b	0	0.2	0.001	0.00	0.003	0.001	0.000	0.002
ρ_v	-0.99	0.99	0.86	0.77	0.95	0.85	0.69	0.97
σ_v	0	1	0.20	0.12	0.28	0.2	0.1	0.3
ρ_μ	-0.99	0.99	0.85	0.72	0.99	0.46	-0.4	0.99
σ_μ	0	0.2	0.01	0.003	0.026	0.009	0.00	0.01
ϕ_d	0	8	3.9	1.33	6.8	4.56	2.14	7.36
ϕ_a	0	8	3.2	0.7	5.6	3.44	0.34	6.5
ϕ_f	0	8	3.8	0.22	6.9	5.26	1.94	7.99
ϕ_m	0	8	3.9	0.24	7.4	2.95	0.42	5.11
ψ	0	5	0.33	0.0032	0.82	0.22	0.001	0.49
Measurement errors								
σ_y^{me}	0.01	$\sqrt{0.13}$	0.011	0.010	0.012	0.011	0.010	0.0123
σ_c^{me}	0.01	$\sqrt{0.19}$	0.012	0.010	0.015	0.013	0.010	0.016
σ_i^{me}	0.01	$\sqrt{0.51}$	0.018	0.1	0.026	0.024	0.010	0.037
σ_{tby}^{me}	0.01	$\sqrt{0.13}$	0.013	0.010	0.016	0.013	0.010	0.0163
Log-Lik.			596.88			595.37		

Note: Model (1) refers to the multi-sector model estimated on data used by SGU (from 1960 to 2011) under the assumption of no shock-transmission to domestic prices. Model (2) refers to the case where domestic producers are given the possibility to adjust prices following shocks on wolrd commodity prices.

the quality of fit of second moments to the data is not significantly improved (see Table 3.4).

The main remarkable result in Table 3.3 is the minor effect of world shocks mediated by multiple prices with a cumulated share of variance of around 12% for real output, versus a measure of 68% predicted by the empirical SVAR model in FSGU. The result of 12% is however extremely close to the one obtained by SGU when assuming world shocks mediated by terms-of trade, for instance through an empirical SVAR study confirmed by a DSGE model (13%). In the present paper, the DSGE model does not confirm that world shocks mediated by multiple prices play a more important role than when mediated by terms-of-trade; hence, results do not support the conclusion of FSGU about the potential under-estimation of world shocks by a single price measure like terms-of-trade. We propose to investigate this important issue in more details with estimations of the model under the assumption of world shocks mediated by only one commodity price.

3.4.2 Single-world-price specifications

We consider now the three cases where world shocks are mediated by only one of the three commodity prices. In each model, the price of a commodity is supposed to follow an AR(1) process. Estimates of parameters of each AR(1) process are reported in Tables 3.11, 3.12 and 3.13 displayed in appendix. We find that results range from 0.04 to 0.08 for standard deviations of shocks, and from 0.51 to 0.65 for autocorrelation coefficients. Other parameter estimates of the model remain robust to the different specifications. The variance decomposition analysis is presented in table 3.3. The cumulated share of variance explained by each price reaches 11.3% for real output, hence, a little less than the share of variance obtained with a multiple price specification. Results indicate also that only one commodity price is not sufficient to uncover the channels through which world shocks propagate to the domestic economy.

The best transmitter appears to be the agriculture commodity price, doing slightly better than the fuel commodity price (6.1 vs 5.3). The impact of this best single transmitter remains low compared to the one of the multiple price speifiation, which appears in consequence more appropriate. However, admitting the need of multiple commodity prices does not mean that any single agregate price specification under-estimates the effects of world shocks. Before coming to this conclusion, it is indeed necessary to check through a simulation exercise if aggregating sectors leads to same results as in the case

TABLE 3.3: Variance Decomposition Predicted by the Model

Shock	$g_{\hat{Y}}$	$g_{\hat{C}}$	$g_{\hat{I}}$	TBY
Model (1): three world price p_a, p_f, p_m				
Nonstationry Tech.	75.6	51	44.9	14.4
Stationary Tech.	7.6	4.3	2.2	0.7
Preference	2.9	38.3	10.5	57.4
Country premium	1.8	4.6	39.2	24.2
Agriculture Prices	6.5	1.24	1.6	1.9
Fuel Prices	3.4	0.14	0.5	0.84
Metal Prices	2.2	0.22	1.05	0.56
Model (2): adjustment of p_d				
Nonstationry Tech.	82.4	62.2	55.6	30.4
Stationary Tech.	3.65	1.4	0.6	0.46
Preference	1.68	30.9	6.04	51.6
Country premium	0.86	2.64	21.32	12.23
Agriculture Prices	6.2	1.7	5.52	3.5
Fuel Prices	4.05	0.56	3.11	0.86
Metal Prices	1.17	0.64	7.83	0.9
Model (3): one world price p_a				
Nonstationry Tech.	83.4	54.3	41.9	9.9
Stationary Tech.	4	1.8	0.7	0.2
Preference	4.3	35.7	13.4	51.8
Country premium	22	6.9	42.7	37.3
Agriculture Prices	6.1	0.7	0.4	1.1
Model (4): one world price p_f				
Nonstationry Tech.	71.6	45	37.1	10.1
Stationary Tech.	16.4	9.1	4.5	1
Preference	4.1	38.7	13.2	52
Country premium	2.5	6.1	43.5	36.2
Fuel Prices	5.3	1.2	1.7	0.7
Model (5): one world price p_m				
Nonstationry Tech.	81.5	52.4	42.1	13.2
Stationary Tech.	12.4	7	3.5	0.6
Preference	3.5	34.8	11.1	48
Country premium	2.5	5.8	42.9	38.1
Metal Prices	0.03	0.03	0.44	0.05

Note: Variables prefixed by g denote growth rates. Model (1) refers to the SOE-IO model estimated under the assumption of no effects on domestic prices SOE-IO Model 2 refers to SOE-IO model estimated under the assumption of adjusted domestic prices. Model (3), (4) and (5) refer to the model estimated under the assumption of only one commodity used as a world shock transmitter, respectively, agriculture, fuel and metals.

of a single commodity price.

TABLE 3.4: Second moments of Data and Models

Moments	Data	Stderr	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
$\sigma(g_{\hat{Y}})$	2.5	(0.4)	2.8	3.02	2.7	2.7	2.67
$\sigma(g_{\hat{C}})$	3.5	(0.3)	3.5	3.8	3.5	3.6	3.5
$\sigma(g_{\hat{I}})$	6.9	(0.6)	6.6	6.6	6.6	6.47	6.5
$\sigma(TBY)$	3.5	(0.4)	5.8	7.4	5	4.45	4.2
$\rho(g_{\hat{Y}}, g_{\hat{C}})$	0.84	(0.1)	0.76	0.8	0.78	0.77	0.79
$\rho(g_{\hat{Y}}, g_{\hat{I}})$	0.85	(0.1)	0.63	0.69	0.63	0.62	0.64
$\rho(g_{\hat{Y}}, TBY)$	-0.17	(0.09)	-0.06	-0.07	-0.08	-0.09	-0.14
$\rho(TBY, g_{\hat{C}})$	-0.28	(0.1)	-0.16	-0.14	-0.19	-0.22	-0.24
$\rho(TBY, g_{\hat{I}})$	-0.075	(0.03)	-0.07	-0.09	-0.08	-0.09	-0.13
$\rho(g_Y)$	0.21	(0.2)	0.22	0.3	0.22	0.23	0.28
$\rho(g_{\hat{C}})$	-0.02	(0.1)	0.1	0.12	0.11	0.09	0.118
$\rho(g_{\hat{I}})$	0.26	(0.1)	-0.03	-0.03	-0.04	-0.03	-0.03
$\rho(TBY)$	0.66	(0.1)	0.53	0.89	0.84	0.84	0.84
$\rho_{t-2}(TBY)$	0.35	(0.1)	0.75	0.8	0.73	0.73	0.726
$\rho_{t-3}(TBY)$	0.15	(0.1)	0.67	0.74	0.65	0.64	0.635
$\rho_{t-4}(TBY)$	0.04	(0.05)	0.6	0.69	0.59	0.57	0.563

Note: Model (1) refers to the SOE-IO model estimated under the assumption of no effects on domestic prices. Model 2 refers to SOE-IO model estimated under the assumption of adjusted domestic prices (we suppose producers of the domestic sector adjust prices with on time delay). Model (3), (4) and (5) refer to the model estimated under the assumption of only one commodity used as a world shock transmitter, respectively, agriculture, fuel and metals.

3.4.3 Shocks transmission and sector agregation

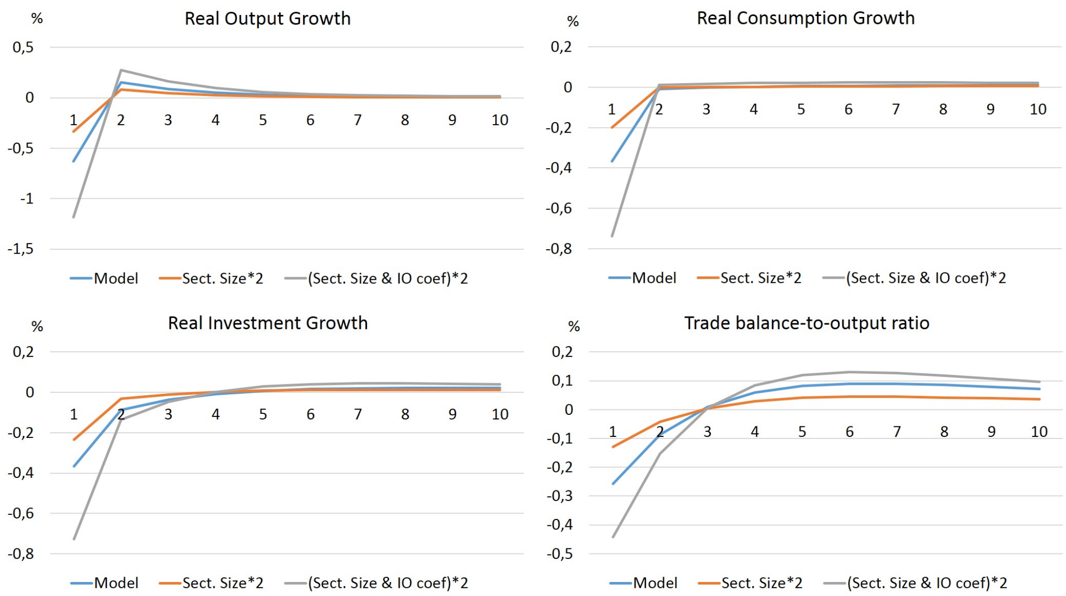
In chapter 2, we have explained that a shock affecting the price of an export good transmits positively to the domestic economy through the supply side, and negatively through the global demand side. Indeed, depending on the relative size of the export good sector, the higher selling price on world markets implies a higher profit in the export good sector and hence, higher remunerations which encourage production and growth. On the other side, a higher price of a domestic product is also synonym of higher production and consumption prices, which discourage production and efforts in all other sectors of the domestic economy. In this previous chapter, we argue that terms of trade shocks should most likely have moderate impacts on a domestic economy given they result from the compensation of those two opposite effects (i.e. a net effect should most likely be relatively small in general). In other words, we already know that the impacts of external shocks on prices increase with the relative sector size, and decrease with rthe rate of domestic absoprtion.

In this section, the goal is not to investigate those effects that we already know from chapter 2. Precisely, we are interested in measuring the impact of shocks in prices as we agregate sectors and use a single corresponding price index as transmitter. Quantitatively, this is actually equivalent to increasing both the supply and demand size in same proportions. If the impact of the price shock remains identical, then the use of an agregate single price index as a world shock transmitter leads to an under-estimation of impacts. If the impact increases accordingly, then an agregate price index as terms-of-trade for example, can not be considered as inappropriate. We propose to answer the question through a simulation exercise based on the model estimated under the assumption of world shocks mediated by the agriculture price (Model 3).

Figure 3.1 displays impulse responses of macroeconomic indicators following a price increase of agriculture products on world markets. The estimated initial model predicts a negative effect on real output on impact before a growth cycle takes place. Starting from this model, we double in a first step the size of the agriculture sector everything equal, by increasing the parameter b_a accordingly. As expected, the larger the commodity sector, the greater the positive impact on real output following a price increase on world markets. It appears indeed that the growth rate of real output decreases less when the size of the agriculture sector is doubled. In view of the variance decomposition analysis displayed in Table 3.5 the share of variance of real output explained by the price shock has not increased with the sector size. It is even significantly lower (2.11% versus 6.1%).

Under the case where global demand for agriculture commodities increases proportionnally to the sector size, for instance doubled by adjusting parameters κ_i, ν_{ij}, and ζ_i accordingly, the price shock appears to impact the domestic economy more intensively than in the initial case. Impulse responses are amplified, with for instance a larger negative effect on real output on impact. Table 3.5 shows also that the share of variance of output explained by the agriculture price shock is relatively higher with 19.5%.

FIGURE 3.1: Impulse Responses: Role of sector size and IO coefficients



Note: The figure presents impulse responses following a price increase in agriculture. Starting from the model estimated under the assumption of world shocks mediated by the agriculture price only, the figure presents responses when doubling the size of the agriculture sector, and when doubling both the sector size and the shares of employment of agriculture products (in terms of consumption and inputs).

TABLE 3.5: Shares of variance explained by shocks on the agriculture price index

Shock	$g_{\hat{Y}}$	$g_{\hat{C}}$	$g_{\hat{I}}$	TBY
Model (3): one world price p_a	6.1	0.7	0.4	1.1
Doubling Supply size	1.87	0.21	0.16	0.28
Doubling Supply and Demand size	19.5	2.6	1.75	3.85

Note: Variables prefixed by g denote growth rates. The table presents shares of variances explained by shocks on the agriculture commodity price. Starting from the model estimated under the assumption of world shocks mediated by the agriculture price only, the table presents the impact of doubling the size of the agriculture sector, and the impact of doubling both the size of the sector and the shares of consumption and employment of agriculture products.

Hence, we confirm through this example that aggregating sectors may not necessarily cause under-estimation of price shock transmissions, meaning that terms-of-trade can not be considered as inappropriate to measure the impact of world shocks on prices of traded goods . Furthermore, as explained previously, the DSGE model has not confirmed that commodity price shocks play a more important role than terms-of -trade shocks, as predicted by SVAR models. There is therefore a clear disconnect between theoretical and empirical conclusions that needs to be clarified. A priori, two potential explanations might be proposed. On the one hand, it could be that the SVAR model tends to over-predict the role of commodity prices because it fails to account for relevant structural information about the economy. The over-prediction would be in that case the result of biased estimations. Note that in the case of Argentina, the SVAR model predicts that the three commodities representing only 10% of the GDP, explain 68% of its volatility. Considering this result as right implies that the 'remaining' 90% of GDP should be relatively stable. However, if it is actually not the case, and this 90% share of GDP fluctuates for example in a comparable size as the three commodity sectors over the studied period, then the estimation of 68% of the volatility of GDP explained by commodity price shocks is necessarily biased. This type of bias is known to be reduced with the use of a large data set and for instance, Fernandez et al. (2017) draw their conclusion about the role of commodity prices on the basis of 138 countries. Hence, if empirical results can be challenged at the country level (eventually Argentina for example), the rejection of their conclusion appears less possible and the question becomes: what is wrong with the theoretical DSGE model ?

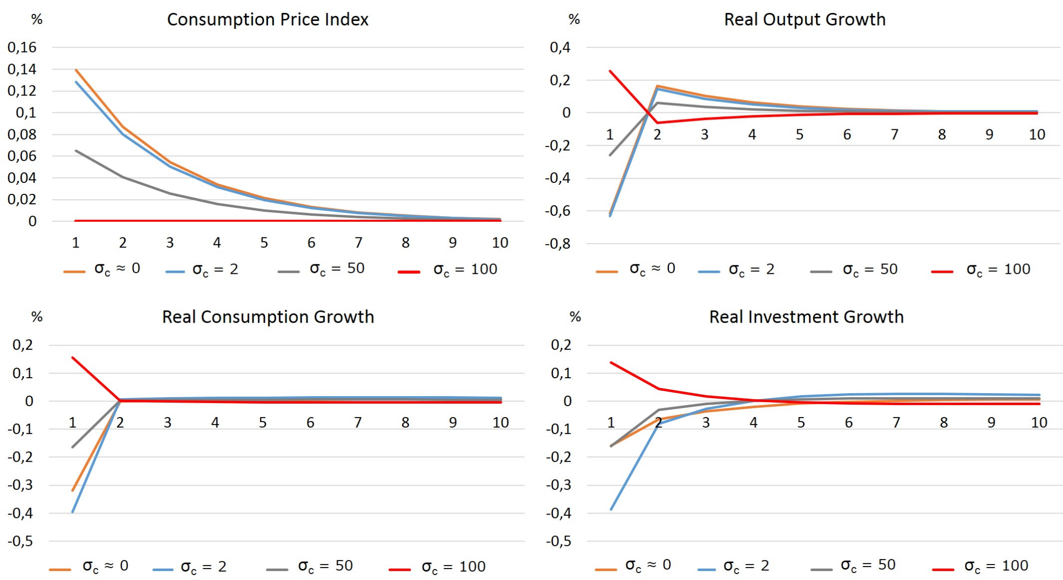
A common suggestion in the literature to bring theoretical results close to empirical ones regarding the role of commodity price shocks, is to include a financial amplifying mechanism. Many contributions explain indeed that financial actors relate price variations of popular commodities of countries to their respective level of risk. Following a favorable commodity price shock for example, reactions of financial actors are such that the currency of the exporting country appreciates and the interest rate at which it contracts foreign debt declines. The country benefits therefore from favorable financial conditions for expansion, despite its global export good sector could actually be confronted with a contraction of output. This explains why terms of trade shocks are found to play a moderate role compared to commodity price shocks in explaining business cycles. As defended by the present paper, it might indeed not be a statistical or a quantitative agregation matter of a single price specification as suspected by Fernandez et al (2017).

3.4.4 The role of the elasticity of substitution

This section addresses quantitatively the role of the elasticity of substitution which has been initially equal to 2. The question is to know if results regarding the effects of world shocks conditionnal on a price measure are sensitive to the degree of elasticity of substitution. Specifically, do the results support the conclusion of Fernandez et al. (2017) about a high contribution of commodity prices to business fluctuations of Argentina ?

I propose to test different degrees of elasticity of substitution between goods, and to recall the same model as in the previsous section where world shocks are supposed mediated by the agriculture commodity price. I also maintain the simplifying assumption of same elasticities of substitution for any type of employment of goods in the economy, with $\sigma_C = \sigma_I = \sigma_V$. As explained in chapter 2, the more the goods become substitutes, the more the effects on real macroeconomic indicators become positive following the price increase of the commodity on world markets. The possibility to substitute more means indeed the possibility to 'escape' more the price increase, which attenuates in consequence the response of price indexes and the contraction of output in other sectors of the domestic economy. This is exactly what

FIGURE 3.2: Impulse Responses: Role of the elasticity of substitution



Note: The figure presents impulse responses following a price increase in agriculture in the estimated model under the assumption of world shocks mediated by the agriculture price only. The different responses correspond to different elasticities of substitution between goods.

figure 3.2 depicts. Results indicate clearly the need of a relatively high elasticity of substitution to observe significant differences on the dynamics of real macroeconomic aggregates. Indeed, a degree of elasticity of substitution equal to 2, generates results close to the perfect complement case (a plausible assumption given the different nature of goods). The response of real output remains also negative with an elasticity of $\sigma_C = 50$. In any case, the share of variance of real output explained by world shocks remains always low (6.1% for the perfect complement case and 1.1% for the perfect substitute case approximated with $\sigma_C = 100$.

3.5 Conclusion

The use of multiple commodity prices s a world shock transmitter is found to explain a large fraction of business cycles of emerging countries (33%). This prediction coming from empirical SVAR models contradicts the one obtained when using the agregate terms-of-trade index as a world shock transmitter (13%). In a recent paper, Fernandez et al. (2017) study the question of the choice of the best transmitter through the lens of an SVAR model and conlude that a multiple price specification is preferable for statistical reasons.

I challenge this conclusion with a study based on a theoretcial multi-sector DSGE model. The estimation on data of Argentina does not confirm that multiple prices play a more important role than terms-of-trade. The share of variance of output explained is indeed equal to 12%, hence, a result close to the one obtained by Schmitt-Grohe and Uribe (2018) when using the terms-of-trade as a world shock transmitter (13%). The analysis through a simulation exercise helps understanding that there might actually be no difference between predictions using agregated and disagregated price measures. We conclude in consequence that if empirical predictions of SVAR models diverge regarding the impact of multiple prices and terms-of-trade, it might be because commodity price shocks are associated to financial amplification mechanisms which tend to produce co-movements with output. This is not the case for terms-of-trade shocks. I conclude therefore that the question of how to capture efficiently the impacts of world shocks is not a matter of number of transmitting variables as suspected by Fernandez et al. (2017).

3.6 References

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3.7 Appendix

TABLE 3.6: Estimation of Models on GPU data from 1900 to 2005

			Posterior distribution					
	Prior distribution		GPU Model (1900-2005)			SOE-IO Model (1900-2005)		
Parameter	Min	Max	Median	5%	95%	Median	5%	95%
ρ_g	-0.99	0.99	0.35	-0.66	0.83	0.173	-0.58	0.9
σ_g	0	0.2	0.007	0.001	0.027	0.0109	0	0.0245
ρ_b	-0.99	0.99	0.87	0.79	0.93	0.8636	0.78	0.95
σ_b	0	0.2	0.033	0.028	0.038	0.0146	0.1260	0.0169
ρ_v	-0.99	0.99	0.86	0.74	0.93	0.8	0.72	0.9
σ_v	0	1	0.51	0.37	0.8	0.44	0.32	0.55
ρ_μ	-0.99	0.99	0.91	0.83	0.97	0.89	0.82	0.97
σ_μ	0	0.2	0.056	0.034	0.08	0.08	0.06	0.1
ϕ	0	8	4.6	3	6.5			
ϕ_d	0	8				5.3	3.4	7.2
ϕ_a	0	8				4.5	1.6	8
ϕ_f	0	8				4.6	1.7	7.96
ϕ_m	0	8				4.4	1.55	7.85
ψ	0	5	2.8	1.3	4.6	3.96	2	5.8
Measurement errors								
σ_y^{me}	0.01	$\sqrt{0.13}$	10^{-4}	10^{-4}	10^{-4}	0.01	0.010	0.011
σ_c^{me}	0.01	$\sqrt{0.19}$	10^{-4}	10^{-4}	0.0002	0.012	0.010	0.014
σ_i^{me}	0.01	$\sqrt{0.51}$	0.0012	0.0002	0.0032	0.0427	0.018	0.06
σ_{tby}^{me}	0.01	$\sqrt{0.13}$	10^{-4}	10^{-4}	10^{-4}	0.010	0.010	0.011
Log-Lik.			600.5854			608.2		

Note: GPU Model (1900-2005) refers to the model of Garcia-Cicco et al. (2010) estimated on their larg data set from 1900 to 2005. Model (1900-2005) refers to the proposed multi-sector model estimated on the same data set with no price shocks. This estimation is performed to check if results of the multi-sector model remains close to the aggregate one with same conclusions.

TABLE 3.7: Estimation of the Models on SGU data from 1960 to 2011

			Posterior distribution					
	Prior distribution		GPU Model (1960-2011)			SOE-IO Model (1960-2011)		
Parameter	Min	Max	Median	5%	95%	Median	5%	95%
σ_g	0	0.2	0.019	0.014	0.024	0.019	0.008	0.028
ρ_g	-0.99	0.99	0.6	0.36	0.81	0.59	0.39	0.8
σ_a	0	0.2	0.031	0.00	0.087	0.0013	0.00	0.0048
ρ_a	-0.99	0.99	0.28	-0.4	0.99	0.34	-0.16	0.99
σ_v	0	1	0.162	0.095	0.23	0.2	0.12	0.27
ρ_v	-0.99	0.99	0.83	0.73	0.93	0.84	0.72	0.95
σ_μ	0	0.2	0.007	0.0018	0.011	0.011	0.004	0.018
ρ_μ	-0.99	0.99	0.86	0.74	0.99	0.86	0.77	0.98
ϕ	0	8	2.6	0.94	4.03			
ϕ_d	0	8				4.3	2	6.5
ϕ_a	0	8				4.3	1.3	7.4
ϕ_f	0	8				3.3	0.21	7.96
ϕ_m	0	8				3.5	0.55	6.87
ψ	0	5	0.35	0.007	0.71	0.48	0.03	0.95
			Measurement errors					
σ_y^{me}	0.01	$\sqrt{0.13}$	0.011	0.01	0.012	0.011	0.01	0.0127
σ_c^{me}	0.01	$\sqrt{0.19}$	0.012	0.01	0.012	0.01	0.01	0.0147
σ_i^{me}	0.01	$\sqrt{0.51}$	0.019	0.01	0.027	0.018	0.01	0.02
σ_{tby}^{me}	0.01	$\sqrt{0.13}$	0.013	0.01	0.016	0.012	0.01	0.015
Log-Lik.			409.34			411.05		

Note: GPU Model (1960-2011) refers to the model of Garcia-Cicco et al. (2010) estimated on the data set used by Schmitt-Grohe and Uribe (2018) from 1960 to 2011. SOE-IO Model (1960-2011) refers to the proposed multi-sector model estimated on the same data set with no price shocks.

TABLE 3.8: Variance Decomposition Predicted by the Models

Shock	$g_{\hat{Y}}$	$g_{\hat{C}}$	$g_{\hat{I}}$	TBY
GPU Model on GPU data (1900-2005)				
Nonstationry Tech.	7.4	4.3	1.5	0.4
Stationary Tech.	84.2	51.3	15.9	1.3
Preference	5.5	39.1	20.2	19.3
Country premium	2.9	5.2	62.4	78.9
SOE-IO Model on GPU data (1900-2005)				
Nonstationry Tech.	6.3	3.3	1.3	0.3
Stationary Tech.	85.5	52	14.7	0.6
Preference	5.8	33.7	29.9	13.7
Country premium	2.4	11	54.1	85.4
GPU Model on SGU data (1960-2011)				
Nonstationry Tech.	85.3	54.4	54.3	18.5
Stationary Tech.	10.6	4.6	4.5	1.35
Preference	2.2	39.4	6.9	57.2
Country premium	1.9	1.7	34.3	23
SOE-IO Model on SGU data (1960-2011)				
Nonstationry Tech.	81.7	48.1	41.3	11
Stationary Tech.	12.3	6.7	4.4	1.1
Preference	3.3	39.6	10.9	51.4
Country premium	2.7	5.5	43.3	36.5

Note: Cross-checking of Models (the SOE-IO model is estimated under the assumption of no price shocks)

TABLE 3.9: Second moments of Data and Models

Moments	Data (1960-2011)	Stderr	GPU Model (1960-2011)	SOE-IO Model (1960-2011)
$\sigma(g_{\hat{Y}})$	2.5	(0.4)	2.6	2.5
$\sigma(g_{\hat{C}})$	3.5	(0.3)	3.5	3.4
$\sigma(g_{\hat{I}})$	6.9	(0.6)	6.4	6.4
$\sigma(TBY)$	3.5	(0.4)	4.5	4.2
$\rho(g_{\hat{Y}}, g_{\hat{C}})$	0.84	(0.1)	0.78	0.77
$\rho(g_{\hat{Y}}, g_{\hat{I}})$	0.85	(0.1)	0.68	0.65
$\rho(g_{\hat{Y}}, TBY)$	-0.17	(0.09)	-0.14	-0.13
$\rho(TBY, g_{\hat{C}})$	-0.28	(0.1)	-0.24	-0.25
$\rho(TBY, g_{\hat{I}})$	-0.075	(0.03)	-0.11	-0.11
$\rho(g_{\hat{Y}})$	0.21	(0.2)	0.19	0.24
$\rho(g_{\hat{C}})$	-0.02	(0.1)	0.04	0.09
$\rho(g_{\hat{I}})$	0.26	(0.1)	-0.05	-0.04
$\rho(TBY)$	0.66	(0.1)	0.85	0.84
$\rho_{t-2}(TBY)$	0.35	(0.1)	0.73	0.72
$\rho_{t-3}(TBY)$	0.15	(0.1)	0.65	0.63
$\rho_{t-4}(TBY)$	0.08	(0.05)	0.58	0.554

Note:Cross-checking of Models estimated on the same sample from 1960-2011 (the SOE-IO model is estimated under the assumption of no price shocks)

TABLE 3.10: Bayesian Estimates of the VAR system of world prices

			Posterior distribution					
	Prior distribution		Model (1)			Model (2)		
Parameter	Min	Max	Median	5%	95%	Median	5%	95%
a_{da}	-0.99	0.99	-	-	-	-0.0736	-0.4605	0.2789
a_{df}	-0.99	0.99	-	-	-	-0.136	-0.324	0.059
a_{dm}	-0.99	0.99	-	-	-	0.196	0.018	0.364
a_a	-0.99	0.99	0.81	0.65	0.99	0.77	0.561	0.989
a_{af}	-0.99	0.99	-0.41	-0.69	-0.08	-0.56	-0.9	-0.3
a_{am}	-0.99	0.99	0.12	-0.08	0.32	0.23	-0.0056	0.45
a_{fa}	-0.99	0.99	0.69	0.41	0.99	0.59	0.25	0.989
a_f	-0.99	0.99	-0.21	-0.66	0.24	-0.33	-0.88	0.15
a_{fm}	-0.99	0.99	0.39	0.07	0.7	0.5	0.19	0.88
a_{ma}	-0.99	0.99	0.38	-0.04	0.91	0.362	-0.087	0.76
a_{mf}	-0.99	0.99	-0.65	-0.99	-0.33	-0.77	-0.99	-0.57
a_m	-0.99	0.99	0.64	0.41	0.9	0.71	0.5	0.96
σ_{ϵ^a}	0	0.2	0.032	0.023	0.042	0.029	0.02	0.037
σ_{ϵ^f}	0	0.2	0.061	0.020	0.09	0.029	0.0006	0.047
σ_{ϵ^m}	0	0.2	0.0375	0.004	0.0644	0.044	0.027	0.061
$\rho(\epsilon^a, \epsilon^f)$	0	0.2	0.121	0.038	0.2	0.12	0.0446	0.2
$\rho(\epsilon^a, \epsilon^m)$	0	0.2	0.119	0.033	0.2	0.13	0.0424	0.200
$\rho(\epsilon^m, \epsilon^f)$	0	0.2	0.123	0.048	0.2	0.095	0.00	0.17
			Measurement errors					
σ_a^{me}	0.01	$\sqrt{0.1}$	0.019	0.010	0.028	0.0168	0.010	0.024
σ_f^{me}	0.01	$\sqrt{0.1}$	0.056	0.013	0.099	0.077	0.06	0.09
σ_m^{me}	0.01	$\sqrt{0.1}$	0.043	0.010	0.07	0.026	0.010	0.041
Log-Lik.			596.88			595.37		

Note: The table presents estimates of the price system (3.16). Model (1) refers to the multi-sector model estimated under the assumption of no shock-transmission to domestic prices. Model (2) refers to the case where domestic producers are given the possibility to adjust prices following shocks on wolrd commodity prices.

TABLE 3.11: Bayesian Estimates of the AR process: Agriculture price

	Prior distribution		Posterior distribution		
Parameter	Min	Max	Median	5%	95%
a_a	-0.99	0.99	0.625	0.45	0.82
σ_{ϵ^a}	0	0.2	0.0366	0.0285	0.0453

Note: Here, the model is estimated by considering only a single price shock process. World shocks are supposed mediated by only the agriculture price.

TABLE 3.12: Bayesian Estimates of the AR process: Fuel price

	Prior distribution		Posterior distribution		
Parameter	Min	Max	Median	5%	95%
a_a	-0.99	0.99	0.65	0.48	0.86
σ_{ϵ^a}	0	0.2	0.08	0.06	0.1

Note: Here, the model is estimated by considering only a single price shock process. World shocks are supposed mediated by only the agriculture price.

TABLE 3.13: Bayesian Estimates of the AR process: Metal price

	Prior distribution		Posterior distribution		
Parameter	Min	Max	Median	5%	95%
a_a	-0.99	0.99	0.51	0.29	0.71
σ_{ϵ^a}	0	0.2	0.058	0.044	0.073

Note: Here, the model is estimated by considering only a single price shock process. World shocks are supposed mediated by only the agriculture price.

TABLE 3.14: Calibration and Estimation of parameters

Parameters	Domestic	Agriculture	Fuel	Metal
B_j	1.7	1.3	1.2	1.22
ζ_i	0.939	0.188	0.188	0.188
κ_i	0.939	0.188	0.188	0.188
ν_{id}	0.78	0.55	0.3	0.188
ν_{ia}	0.939	0.188	0.188	0.188
ν_{if}	0.729	0.182	0.182	0.638
ν_{im}	0.939	0.25	0.188	0.188

Parameters B_j are calibrated to match the size of sectors which are respectively, 90%, 5%, 2.3% and 2.1% for the domestic, agriculture, fuel and metal sector (the absolute levels allows to reach a consumption-output ratio of 82%.) Parameters ζ_i and κ_i are set to approximate a share of 88% allocated to the domestic good, and relatively small shares of around 3.5% for commodities.

APPENDIX

A3. The theoretical model: Resolution

$$\frac{\partial \mu_t U(C_t, L_{at}, L_{ft}, L_{mt}, L_{dt})}{\partial C(X_t)} = \lambda_t P_t^C \tag{3.20}$$

$$\frac{\partial \mu_t U(C_t, L_{at}, L_{ft}, L_{mt}, L_{dt})}{\partial L_{jt}} = \lambda_t w_{jt} \tag{3.21}$$

$$\lambda_t = \beta(1 + r_t) E_t \lambda_{t+1} \tag{3.22}$$

$$\begin{aligned} \lambda_t \left(P_t^{I_j} + \phi_j \left(\frac{K_{jt+1}}{K_{jt}} - g \right) \right) = \\ \beta E_t \lambda_{t+1} [u_{jt+1} + (1-\delta) P_{t+1}^{I_j} + \frac{K_{jt+2}}{K_{jt+1}} g_{t+1} (\frac{K_{jt+2}}{K_{jt+1}} g_{t+1} - g) \\ - \phi_j / 2 (\frac{K_{jt+2}}{K_{jt+1}} g_{t+1} - g)^2) \end{aligned} \tag{3.23}$$

We can easily show that this resolution with aggregate variables is equivalent to the one where we maximize the objective function with respect to C_i and to Kij.

General Conclusion

Several contributions of this thesis can be summarized. From the first chapter, one learns that the influential conclusion of Garcia-Cicco et al. (2010) according to which emerging countries are not faced with permanent productivity shocks, is seriously questionable. On the one hand, augmenting the utility function to include a plausible direct preference for wealth accumulation in countries exposed to credit and financial frictions, tends to reduce the role of temporary productivity shocks to the detriment of permanent productivity shocks in explaining business cycles of emerging countries. On the other hand, changing the way of calibrating a strutural parameter (fos instance calibrating the steady-state external debt to match the observed sovereign debt-to-GDP ratio rather than the observed trade-balance-to-output ratio) leads to reinforce the estimated role of the permanent productivity shock as well, and to increase the significance of the degree of prefence for wealth. The resulting log-likelihood of the estimation is relatively higher and the quality of fit of the model is comparable. As a conclusion, chapter 1 gives back credit to the hypothesis of Aguiar and Gopinath (2007), stating that emerging countries are confronted with unfavorable consequences of frequent policy regime switches and unstability.

From the second chapter, one learns that terms-of-trade shocks play a minor role in explaining business cycles of emerging countries contrary to conventional wisdom. Empirircal and theoretical reulst of Schmitt-Grohe and

Uribe (2018) are indeed confirmed and explanations are completed well beyond the matter of the measure of theoretical variables (they show for instance the importance of deflating theoretcial variables properly). An important further reason why terms-of-trade shocks do not generate the economic boom as thought in the literature since Mendoza (1995) and Kose (2002), is that countries often consume and use their own exported goods domestically. Extending therefore the SOE model to include an explicit input-output structure calibrated accurately for each country, makes important sense if one is interested in gauging the role of terms-of-trade shocks and explaining the country diversity in terms of impact. The quality of fit of the extended model is indeed impoved compared to the standard model of Scmitt-Grohe and Uribe (2018).

From the thrid chapter, one understands that the choice of a single agregate price (like terms-of-trade) as a world shock transmitter does not lead to under-estimate the role of world shocks because of a statistical mispecification. The relative price variations of traded goods (included within the terms-of-trade index) do not explain a large fraction of output volatility. The theoretical model shows indeed that a multiple commodity price specification used as a world shock transmitter, leads to the same result as the terms-of-trade specification in terms of share of variance of output explained (12%). The reason why empirical predictions of the SVAR models diverge is because commodity price shocks are associated to financial amplification mechanisms which tend to generate co-movements with output. This is not the case for terms-of-trade shocks. As a conclusion, if one is interested in measuring the impacts of world shocks, the multiple price specification is preferable to account for the financial amplifying mechanisms that apply for some particular commodities (popular ones). In other words, even within a theoretical model, sectors should be disagregated so that amplifying mechanisms can be associated properly to the corresponding particular commodities.