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Central Bank Review (CBR)

Provided in Cooperation with:

Central Bank of The Republic of Turkey, Ankara

Suggested Citation: Coskun, Sevgi (2019) : Labour market fluctuations: An RBC model for emerging countries, Central Bank Review (CBR), ISSN 1303-0701, Elsevier, Amsterdam, Vol. 19, Iss. 4, pp. 141-153,
<https://doi.org/10.1016/j.cbrev.2019.11.002>

This Version is available at:

<https://hdl.handle.net/10419/217339>

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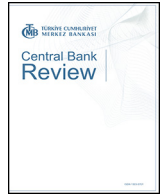
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Labour market fluctuations: An RBC model for emerging countries[☆]

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ARTICLE INFO

Article history:

Received 9 August 2019
 Received in revised form
 25 October 2019
 Accepted 17 November 2019
 Available online 4 December 2019

JEL classification:

E31
 E32
 E52
 F41
 O50

Keywords:

Labour market
 Emerging market economies
 Real business cycle model
 Labour wedge

ABSTRACT

In this paper, we examine the labour market properties of business cycle fluctuations for a group of 15 emerging market economies (EMEs) and the US using annual data from 1970 to 2013. We find that on average, the hours worked and employment volatility (relative to output volatility) are lower, while the volatility of productivity and wages are 2–3 times higher in EMEs compared to the US. We then assess the performance of a standard RBC model and an augmented RBC model with capacity utilization, investment adjustment cost and indivisible labour with temporary and permanent productivity shocks to explain labour market facts observed in the data. We find that these models fail to explain labour market fluctuations in the business cycles of these countries, but the model with investment adjustment cost improves the performance of relative volatility of wages and hours, as well as the cyclicity of hours, compared to the standard RBC model. Lastly, we investigate the cyclical properties of the labour wedge and find that the total labour wedge (relative to output volatility) is more volatile over the business cycle in emerging economies (1.72) compared to the US (0.95). Further, fluctuations in the total labour wedge reflect the ones in the household component rather than the firm component of the wedge in EMEs and the US.

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1. Introduction

In developed markets, the quantitative analysis of business cycle fluctuations has long been of interest to researchers since the work of Kydland and Prescott (1982).¹ It has been found that hours worked fluctuate more than productivity, as this is almost as volatile as output. Labour productivity and employment are more volatile than real wages. Such analysis is also an old issue for emerging market economies (EMEs), but it has only recently been revived within equilibrium business cycle models. It is well known in the relevant literature, where the frictionless real business cycle (RBC) model has received considerable attention as being incapable of replicating the second moments of labour market dynamics; however, it tends to perform well in explaining a good portion of

aggregate fluctuations such as output, consumption and investment.² Most analyses have focused on developed countries, predominantly on the US, while other markets in the economy have remained unexplored. The aim of the paper is, first, to present the key labor market dynamics of business cycle fluctuations using annual data in EMEs and then to assess the performance of a standard RBC model and an augmented RBC model with capacity utilization, investment adjustment cost and indivisible labor with temporary and permanent productivity shocks to explain those facts. We lastly investigate the fluctuations of total labor wedge (the discrepancy between a representative household's marginal rate of substitution between consumption and leisure and the marginal product of labour) by decomposing it into the household component of labor wedge and the firm component of labor wedge to explore which of these two component are mostly responsible for business cycle fluctuations of the total labor wedge in EMEs.

[☆] I am grateful to Miguel Leon Ledesma, Peter J. N. Sinclair, Mathan Satchi and audiences at the MMF Conference (Bath), EcoMod Conference (Lisbon), ICMAIF Conference (Crete) as well as seminar participations at Kent and two anonymous referees at the CBR for valuable comments and suggestions.

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Peer review under responsibility of the Central Bank of the Republic of Turkey.

¹ See also Backus and Kehoe (1991), Stock and Watson (1999) and Ohanian and Raffo (2012).

² These have then led to a whole branch of the literature addressing these problems by introducing matching frictions. See Christiano and Eichenbaum (1992), Hansen and Wright (1992), Fairise and Langot (1994) and Fiorito and Kollintzas (1994). These studies present some basic stylised facts of labour dynamics (such as productivity and hours worked) and find that the standard RBC model cannot account for these facts in the US and G7 countries.

The interest in this topic has been spurred on for several reasons. First, aggregate fluctuations in EMEs are different from those in developed countries.³ For example, in emerging economies, output is twice as volatile as it is in developed countries, and, wages are highly volatile and pro-cyclical. Moreover, the variability of employment in emerging countries is about half the variability of output.⁴ Second, EMEs have different labor market institutions and their market behaviour is substantially different compared to developed countries. For example; flexibility in contracts, employment protection, firing and hiring costs, and the unions in these countries are quite different from those in developed countries. Furthermore, EMEs have less wage rigidity, larger informal sectors and less social protection, unemployment benefits.⁵ Because of these differences between EMEs and developed countries, their reaction to changes in the macroeconomic fluctuations will be different and this makes these countries a good benchmark to compare the models of business cycle fluctuations. That's why we are interested in labor market fluctuations of business cycles to know whether RBC models fit the features of these economies given that the institutions are different. Finally, the stylised facts of the labour market in EMEs are not as well known as those in developed countries, and there is no consensus on these economies. [Agenor et al. \(2000\)](#) and [Male \(2010\)](#) have pointed out that the results depend on which countries are included in the analysis, as [Rand and Tarp \(2002\)](#) have shown that the stylised facts of business cycles across emerging countries are more diverse than those of the developed countries. It is important to ensure that the stylised facts are as accurate as possible since they are a crucial basis for the construction of a model.

We first systematically document some stylised facts of the labour market properties of the business cycle in EMEs for the period 1970–2013. Then we compare the results with available features of the business cycles in 15 emerging countries with the US. For this analysis, we use sufficient annual data (the sample lengths are long enough to measure business cycles) to provide an accurate picture of labour market properties of business cycle fluctuations.⁶ The data we collected shows that the average volatility of wages and productivity relative to output volatility in emerging countries is about 2–3 times higher than that of the US. Moreover, fluctuations of the extensive margin (0.55) are mostly responsible for fluctuations in the total hours worked (0.64) in these economies, rather than fluctuations in the intensive margin (0.26). Another important finding of this study is that the correlations among employment, hours worked per employed and total hours worked with output in the US are much higher than in EMEs, whereas there are no significant differences in the cyclicalities of real wages and productivity between emerging economies and the US. These results reveal that the labour markets in EMEs adjust more through prices, while the quantities are subdued.

Motivated by these stylised facts, we then investigate whether a set of variants of the RBC model, with no nominal rigidities, can reproduce the labour market features observed in the data from emerging countries. We first look at the performance of the most standard frictionless RBC model as a benchmark model, driven solely by permanent and temporary productivity shocks, as in [Aguar and Gopinath \(2007\)](#). In the data, we observe that the

behaviour of labour market variables in emerging economies differ from each other. On average we find that a frictionless RBC model with temporary and permanent shocks does a good job of matching the relative volatility of hours worked in emerging countries; however, it fails to capture for the rest of the relevant moments in our analysis.

In order to further improve the fit, we introduce an RBC model augmented with capacity utilization, as in [Greenwood et al. \(1988\)](#), investment adjustment costs, as in [Christiano et al. \(2005\)](#) and indivisible labour, as in [Hansen \(1985\)](#).⁷ [Burnside and Eichenbaum \(1994\)](#) find that allowing for capacity utilization in RBC model magnifies and propagates the effects of the shocks over the business cycle. Our results show that this amplification allows an RBC model with this mechanism to generate hours volatility very similar to the data with much smaller shocks, whereas it decreases significantly the ability of the model to produce the relative volatility of wages and productivity for these economies, compared to the standard RBC model. In addition, we find that the RBC model with investment adjustment costs performs better than the simple RBC model for the relative volatility of wages and hours, and for the correlation between hours and output. This mechanism into the RBC model prevents investment quickly responding to change in economic conditions as it mitigates the effect of shocks on capital stock. Hence, hours worked fluctuate less than wages and productivity. Lastly, the model with indivisible labour improves the ability of the model to explain the cyclicalities of productivity for EMEs as well as it increases the relative volatility of hours because individuals are assigned to jobs randomly so there is a large labour supply elasticity. We conclude overall that most of our RBC models fail to explain labour market fluctuations in the business cycles of emerging countries, but that the model with investment adjustment cost improves the performance of the model in regard to the relative volatility of wages and hours, as well as the cyclicalities of hours, compared to the standard RBC model for these countries.

There has been ongoing research to capture the stylised facts of business cycles in EMEs since [Agenor et al. \(2000\)](#) and reconcile these results in the real business cycle model [Aguar and Gopinath \(2007\)](#), [Garcia-Cicco et al. \(2010\)](#), [Neumeyer and Perri \(2005\)](#), [Chang and Fernández \(2010\)](#). These studies have presented various characteristics of business cycles in EMEs focusing on mostly consumption, output, productivity, investment, interest rate, net export and trade balance to output ratio. However, these papers have largely remained silent to explore labor market dynamics over business cycles in EMEs. [Aguar and Gopinath \(2007\)](#) find that RBC model driven by permanent productivity shock does a good job at explaining business cycles features in EMEs. [Garcia-Cicco et al. \(2010\)](#) show that RBC model driven by permanent and temporary shocks does a poor job in explaining business cycle in terms of trade balance and consumption. [Neumeyer and Perri \(2005\)](#) focus on the cyclical movement of interest rate and introduce the model with interest rate shocks or financial shocks. They find that the model can explain the facts well. [Chang and Fernández \(2010\)](#) build an encompassing model that unify stochastic trends with interest rate shocks and financial frictions influenced by [Aguar and Gopinath \(2007\)](#), [Neumeyer and Perri \(2005\)](#). There are very limited studies focusing on the labor market variables. [Li \(2011\)](#) presents the cyclical wage movements in emerging countries and find that the volatility of wages relative to output in developing countries is

³ The seminal paper- [Agenor et al. \(2000\)](#)- present the main stylised facts of macroeconomic fluctuations (output, interest rate, wages, etc.) for a group of 12 emerging countries.

⁴ For details, see also [Boz et al. \(2009\)](#), [Li \(2011\)](#), and [Altug et al. \(2011\)](#).

⁵ See [Freeman \(2007\)](#), [Freeman \(2009\)](#) and [Campos and Nugent \(2012\)](#).

⁶ Typically, the standard business cycle analysis uses quarterly data, but we use annual data, since hours worked data is available only with annual frequency from emerging economies.

⁷ There has been a substantial amount of research that the standard RBC model has been criticized due to its inability to explain some key aggregates variables. See [Mendoza \(1991\)](#), [Burnside and Eichenbaum \(1994\)](#), [Cogley and Nason \(1995\)](#), and [Boileau and Normandin \(1999\)](#). These studies have found that allowing for real frictions improved the ability of the model to account for some features of the data.

almost twice as high as those in developed economies. She also finds that real wages are positively correlated with output. Our results are roughly in line with her results. Also, she builds a small open economy model with productivity shock and countercyclical interest rate, then figure out that the model can explain the high volatility of wage. These studies ignore changes in the hours worked while changes in wages have been examined in the real business cycle model for a small set of EMEs. In this paper, we focus on labor market dynamics including wages and hours worked as well as output and productivity with a larger set of EMEs.

In a frictionless RBC model setting, the marginal rate of substitution (MRS) and the marginal product of labour (MPL) should be equal, but in reality, the observation that these diverge when calibrated to the data, has led to a growing body of literature investigating the so-called labour wedge.⁸ In this study we are also interested in the labour wedge in EMEs and the USA because, firstly, it has relevance in explaining the business cycle, secondly, it provides information about labour market frictions during business cycles, thirdly, it has helped researchers to build a successful model of business cycle. We use the methodology proposed by Karabarounis (2014), who studied the fluctuations in the labour wedge by decomposing this wedge in two: a gap between the MPL and real wage (firm's component) and a gap between the MRS and real wage (household's component). This methodology helps us to see which components are most responsible for the fluctuations in total labour wedge in these economies.

We find that most of the fluctuations in the total wedge come from the household, rather than the firm, component of the labour wedge in both EMEs and the USA. It means that researchers need to focus more on frictions coming from the household side of the model in order to better understand the labour market fluctuations of business cycles in these countries. We also find that the total labour wedge (relative to output volatility) is more volatile in emerging countries (1.72) than in the US (0.95). Note that higher labour wedge would then represent a higher degree of labour market distortions. In particular, the relative volatility of the household component (2.09) and the firm component (1.24) of the labour wedge in the selected emerging countries is 2–3 times higher than the same components in the US. Last, the wedge in the US moves counter-cyclically to output; however, for EMEs, we obtain heterogeneous results. The heterogeneous cyclicalities of the labour wedge shows that labour and product market distortions that affect the labour wedge are different among EMEs.

In this study, our aim is to show how far the various RBC models with permanent and transitory productivity shocks can take us in explaining the labor market fluctuations of business cycles in EMEs, rather than to show a model that incorporates all extensions of the RBC can produce all labor market facts. We believe that we contribute to the limited literature making a more complete description of behaviour of the labor market variables in a large set of group of EMEs covering the sample period 1970–2013. Studies are mostly focusing on developed countries, small set of developing economies or particularly in one country. Also, compared to the existing literature, our paper includes more comprehensive labor market variables, not just wages, it also includes hours worked as well as output and productivity. In addition, we build different types of RBC models with real frictions driven by temporary and permanent shock to match the labor market facts of business cycle in EMEs countries rather than just giving only one model results. Overall, the results in this paper provide a useful guide for researchers about labour market properties of business cycle fluctuations in EMEs and where to introduce frictions to make the

business cycle models more consistent with the data for these economies.

The remainder of this paper is organized as follows. In section 2, we present the data. Section 3 lays out our models and discusses the values of parameters. Section 4 evaluates the performance of the models. Section 5 presents the labour wedge. Finally, section 6 provides concluding remarks.

2. The data

This section intends to provide a set of empirical facts to characterize the properties of the business cycles in emerging countries. We chose countries based on the availability of data; it is difficult to find quality data for certain variables and especially for data on hours worked and wages and there are a lot of missing observations. Hence, we had to reduce the time period for some countries and some variables. Still, we have sufficient annual data to provide an accurate picture of business cycles. However, for some countries, the results show that there is a nature of measurement error in the data as some of our results are not significant. The data on GDP (total GDP, in millions of 1990 US dollars), hours worked, employment, and population (the population aged 15–64) are compiled from the Conference Board Total Economy Database (TED).⁹ The data on wages, which are total compensation of employees, and consumption (household consumption expenditure data at constant (2005) prices in national currency, included non-profit institutions serving households) are collected from the United Nation Statistics Division, which publishes data on national accounts. The real wages data are calculated by deflating the total compensation of employees by the consumer price index. We collected the data for 15 emerging economies (Brazil, Bulgaria, Chile, Colombia, Costa Rica, the Czech Republic, Estonia, Hungary, Jamaica, Mexico, Peru, Slovenia, South Korea, Thailand, and Turkey) and for the US for the period 1970–2013.

We have used annual data instead of quarterly data since hours worked data is available only with annual frequency from emerging countries and all of the variables are converted to *per capita* terms. We construct the variables as follows. *Employment per working age population (e)* is defined as the ratio of the level of employment (E) in the economy to the total working age population (P) of the country; *real GDP per capita (y)* is constructed using real GDP (Y) and the total working age population (P). Then *real wages per hour (w)* is constructed using the total real wages (W) over total hours worked (H) in the dataset. *Labour productivity (p)* is the ratio of real GDP (Y) to total hours worked (H) and, lastly, *consumption per capita (c)* is constructed by dividing household consumption expenditure (C) over total working age population (P). We used two measures of hours worked as in Ohanian and Raffo (2012). First, we constructed *hours worked per employed person (he)*, using total hours worked (H) and employment (E). Second, we constructed *hours worked per working age population (hw)*, using total hours worked and working age population. *Hours worked per working age population (hw)* can be split into two parts as *the intensive margin* (hours worked per employed person) and *the extensive margin* (employed people divided by working age population). The reason for this split is to investigate whether most of the fluctuations in total hours worked come from the extensive margin or from the intensive margin in EMEs.

⁸ See Chari et al. (2007), Shimer (2009) and Ohanian and Raffo (2012).

⁹ The GGDC Total Economy Database is the main source of estimates of hours worked per worker that are comparable across countries. These series are adjusted to reflect most sources of cross-country variation in hours worked, including the contracted length of the work week, statutory holidays, paid vacations, sick days and days lost due to strikes, and they are consistent with output.

Table 1

The standard deviations relative to standard deviations with output in emerging countries and the USA.

Countries	$\frac{\sigma(e)}{\sigma(y)}$	$\frac{\sigma(he)}{\sigma(y)}$	$\frac{\sigma(hw)}{\sigma(y)}$	$\frac{\sigma(p)}{\sigma(y)}$	$\frac{\sigma(w)}{\sigma(y)}$
Brazil	0.76	0.04	0.76	1.07	3.10
Bulgaria	0.89	0.21	0.92	0.90	1.29
Chile	0.45	0.10	0.45	0.84	1.73
Colombia	0.77	0.43	0.91	0.71	1.24
Costa Rica	0.39	0.48	0.62	0.96	1.17
Czech Republic	0.36	0.33	0.51	0.83	0.94
Estonia	0.39	0.27	0.78	0.36	0.91
Hungary	0.75	0.39	0.86	0.73	1.28
Jamaica	0.74	0.38	1.01	0.63	1.19
Mexico	0.35	0.18	0.39	0.83	2.30
Peru	0.24	0.01	0.24	0.91	2.32
Slovenia	0.76	0.37	0.62	0.65	0.51
South Korea	0.59	0.37	0.67	0.71	1.76
Thailand	0.42	0.22	0.50	0.96	1.31
Turkey	0.51	0.21	0.50	1.09	2.68
Average	0.55	0.26	0.64	0.81	1.58
Median	0.51	0.37	0.62	0.83	1.29
USA	0.73	0.27	0.89	0.42	0.77

Note: This table presents the relative standard deviation of the extensive margin (e), intensive margin (he), total hours worked (hw), productivity (p), and wages (w) with the output (y) for the period 1970–2013. The series are logged first and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 100.

To explain business cycle movements, any given data series is expressed in logs and de-trended using a Hodrick-Prescott (HP) filter (Hodrick and Prescott (1981)) with the standard smoothing parameter at 100 for annual data. For each variable j , Table 1 reports the standard deviation relative to the standard deviation of output σ_j/σ_y . Table 2 documents the autocorrelation of output $autocor(y)$ and the correlation with output $corr(j, y)$ for the business cycle frequencies of each emerging country and the US. We present the extensive margin, the intensive margin and hours worked per working age population, as well as productivity and wages to get familiar with the particularities of the business cycle in these economies. Note that we use hours worked per working age population (hw) when we compare the data and model moments in section 4, since we cannot separate employment from hours due to the fact that the whole population is employed in our models, except the model with indivisible labour. Here, on average, are the second order moments of the labour market variables for these economies for the period of 1970–2013:

- The relative volatility of wages is about two times as volatile as the relative volatility of productivity for emerging countries. In terms of quantity, the intensive margin is clearly the least volatile of all.
- The relative volatility of wages (1.58) and productivity (0.81) are almost 2–3 times higher in EMEs than in the US, at 0.77 and 0.42, respectively. Notice that the relative volatility of hours worked (0.89) is higher than that of real wages (0.77) and productivity (0.42) in the US.
- In terms of quantity, the differences between the relative volatilities in emerging countries and the US are not large. The average value of the relative standard deviation of the extensive margin is 0.73 versus 0.27 for the intensive margin in the US, and 0.55 versus 0.26 in emerging economies, respectively. This finding reveals that the extensive margin contributes more to the variability of the total hours in these countries.¹⁰

¹⁰ It would have been worth analysing wages in the informal and formal sectors as well as employment in private and public sector. However, we could not ascertain which sector is most accountable for the variability of these variables in our sample countries, since we are not able to obtain data for these sectors.

Table 2

Autocorrelation and correlation with output in emerging countries and the USA.

Countries	$\rho(y)$	$\rho(e, y)$	$\rho(he, y)$	$\rho(hw, y)$	$\rho(p, y)$	$\rho(w, y)$
Brazil	0.57	0.27	0.14	0.28	0.73	0.68
Bulgaria	0.65	0.64	0.32	0.41	0.55	0.061
Chile	0.61	0.55	-0.01	0.54	0.89	0.67
Colombia	0.71	0.68	0.32	0.73	0.47	0.11
Costa Rica	0.62	0.65	-0.21	0.36	0.75	0.46
Czech Republic	0.58	0.38	-0.04	0.43	0.70	0.27
Estonia	0.73	0.66	0.83	0.92	0.65	0.30
Hungary	0.73	0.63	0.34	0.72	0.54	0.07
Jamaica	0.68	0.55	0.32	0.75	0.17	0.12
Mexico	0.58	0.76	-0.23	0.59	0.93	0.63
Peru	0.60	0.45	0.47	0.47	0.97	0.78
Slovenia	0.74	0.57	0.37	0.71	0.79	0.08
South Korea	0.47	0.75	0.06	0.70	0.74	0.54
Thailand	0.76	0.25	0.23	0.30	0.90	0.81
Turkey	0.48	0.12	-0.14	0.059	0.89	0.41
Average	0.63	0.52	0.18	0.56	0.71	0.39
Median	0.62	0.57	0.23	0.59	0.74	0.41
USA	0.55	0.88	0.61	0.90	0.47	0.54

Note: This table presents the autocorrelation of output (y), correlation of the extensive margin (e), intensive margin (he), total hours worked (hw), productivity (p), and wages (w) with the output (y) for the period 1970–2013. The series are logged first and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 100.

- The co-movement of the labour market variables with output, on average, are all positively correlated for these countries, although at different levels of intensity. Pro-cyclical behaviour corresponds most strongly with productivity (0.71) in EMEs, while total hours worked (0.90) and employment (0.88) correspond most strongly in the US. Compared to the US, the results show that extensive margin, total hours worked and real wages correlate less with output while productivity correlate more with output in emerging countries.
- The correlation of intensive margin (0.61) with output in the USA is about three and half times higher than in the emerging countries (0.18). Lastly, output is somewhat more persistent in the EMEs, with an autocorrelation of 0.63, compared to the USA, at 0.55.

We now turn our attention to the country-level analysis. It is obvious that the properties of labour market fluctuations in many emerging countries differ from each other despite the similar picture emerges among some economies.

- Bulgaria (0.89) shows the highest relative volatility of extensive margin among EMEs while Peru (0.24) is the least volatile. Furthermore, the relative volatility of extensive margin in Brazil, Columbia, Hungary, Jamaica and Slovenia are about as volatile as USA (0.73).
- Brazil, Costa Rica, Thailand and Turkey have the highest volatile productivity among all countries but they do not deviate very much from the average (0.81).
- The relative volatility of wages in Brazil (3.10), Peru (2.32), Mexico (2.30) and Turkey (2.68) are much higher than the average volatility of wages in emerging countries (1.58) while Slovenia shows the lowest wages volatility, at 0.51.
- The co-movement of the labour market variables with output for these economies are positively correlated. However, Costa Rica, Mexico and Turkey are the only countries in our sample where the correlation of intensive margin with output is negative at -0.21, -0.23 and -0.14, respectively.
- Lastly, the correlation of wages and productivity is strongest with output in Peru at 0.78 and 0.97, respectively while Estonia shows the lowest correlation of productivity with output (0.36).

The results confirm the fact that business cycles in emerging countries do not follow the same patterns as in US albeit some similar patterns emerge in country-level analysis. The striking aspect of these results is that the labour markets in EMEs adjust more through prices while quantities are subdued. In the emerging market business cycle literature, Neumeyer and Perri (2005), Boz et al. (2009) and Li (2011) document statistics on labour market variables using semi-annualized, quarterly and both annual and quarterly data, respectively. They find that the quantity variables are less variable and less correlated with output in EMEs compared to the US. Moreover, they find that the volatility of wages relative to output in EMEs is almost twice as high as that in the developed economies, and real wages are positively correlated with output. Our findings on these variables are roughly in line with those studies.

3. The model

The benchmark model we present here, motivated by the findings in the previous section, is a canonical RBC model designed to assess fluctuations in the hours worked, wages, productivity and output of business cycles in EMEs including transitory TFP shock and a permanent labour-augmenting productivity shock as in Aguiar and Gopinath (2007). These shocks have been widely studied in the literature¹¹ which find that the business cycles in emerging countries are mainly driven by shocks to trend growth rather than transitory fluctuations around a stable trend. They interpret the shocks to the trend growth as dramatic changes in institutions and policy in emerging countries. Then we look at several variants of the standard RBC model in the literature. The model consists of households and firms. The households consume, invest in capital and provide labour and capital for the firms. The firms rent labour and capital from the households.¹²

3.1. The standard Real Business Cycle (RBC) model

3.1.1. The households problem

The model economy is populated by a continuum of identical consumers. The preferences of households are defined by consumption, C_t , and hours worked, H_t , and are described by the utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, H_t), \quad (1)$$

where preferences are non-separable:

$$U(C_t, H_t) = \frac{(C_t^\psi (1 - H_t)^{1-\psi})^{1-\sigma}}{1-\sigma}. \quad (2)$$

$E(\cdot)$ denotes the expectation operator, conditional on information available at time t , β is the discount factor between zero and one. As a baseline we use a non-separable utility function which implies that the preferences are non-separable in terms of consumption and hours. $U(\cdot)$ represents a period utility function. The parameter σ is the inverse of the inter-temporal elasticity of substitution for consumption. ψ determines the inverse of the Frisch elasticity of labour supply. This utility function eliminates the wealth effect on leisure; hence, the labour supply depends on wages. We have further simulated the model with the separable

utility function. In contrast to the non-separable utility function, this implies an effect of wealth on leisure. Household maximizes the following lifetime utility function:

$$U(C_t, H_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{H_t^{1+\psi}}{1+\psi}, \quad (3)$$

where χ specifies the preference weight of hours in utility. The Frisch elasticity for labour supply is simply $\frac{1}{\psi}$. The reason we consider both these preferences is to determine whether or not our results are sensitive to differences in preferences used in the analysis.

A household is assumed to own capital, K_t , which accumulates according to the following law of motion:

$$K_{t+1} = (1 - \delta)K_t + I_t, \quad (4)$$

where I_t denotes investment, and δ is the depreciation rate of capital. The households are subject to the following inter-temporal budget constraints:

$$C_t + I_t = W_t H_t + R_t K_t, \quad (5)$$

where W_t denotes the household's real wage rate, and R_t represents the rental rate of capital. Consumers choose to maximize utility subject to capital accumulation and their budget constraints:

$$C_t + K_{t+1} = W_t H_t + R_t K_t + (1 - \delta)K_t. \quad (6)$$

3.1.2. The firms problem

Firms have access to the following Cobb-Douglas production function, which uses capital K_t and labour H_t from households. Production technology takes the form

$$Y_t = e^{z_t} K_t^{1-\alpha} (H_t \Gamma_t)^\alpha, \quad (7)$$

where Y_t is output and $\alpha \in (0,1)$ is the labour share in output. The parameters z_t and Γ_t are stochastic productivity processes which are characterized by different stochastic properties. Specifically the temporary shock, z_t , to total factor productivity is stationary and follows the AR(1) process:

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z, \quad (8)$$

with $|\rho_z| < 1$ as the persistence of the transitory productivity shock and ε_t^z representing an independent and identical distribution (iid) drawn from a normal distribution with a zero mean and standard deviation σ_z . The permanent labour-augmenting productivity shock, Γ_t , is non-stationary and represents the cumulative product of "growth shocks"; it is given by

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^t g_s, \\ \ln(g_t) = (1 - \rho_g) \log(\mu_g) + \rho_g \ln(g_{t-1}) + \varepsilon_t^g.$$

where the parameter g_t represents the rate of growth of the permanent technology shock. $|\rho_g| < 1$ represents the persistence parameter of the process g_t , and ε_t^g represents iid drawn from a normal distribution with a zero mean and standard deviation σ_g . μ_g represents the long run average growth rate of productivity. Notice that shocks to g_t permanently affect labour productivity, Γ_t .

3.1.3. Labour and capital demand

If we assume that the factor market is characterized by perfect

¹¹ See also Chang and Fernández (2010) and Garcia-Cicco et al. (2010).

¹² The equilibrium of the models is derived in Appendix.

competition then the real rental rate on capital R_t^K and real wage W_t is given by

$$\begin{aligned} R_t^K &= e^{z_t} (1 - \alpha) \left(\frac{K_t}{H_t} \right)^{-\alpha} \Gamma_t^\alpha, \\ W_t &= e^{z_t} \alpha \left(\frac{K_t}{H_t} \right)^{1-\alpha} \Gamma_t^\alpha. \end{aligned} \quad (9)$$

3.1.4. Equilibrium conditions in stationary form

Since the model exhibits balanced growth all of the non-stationary variables have to be de-trended. Hence, we normalize all of the variables except H_t with trend shock Γ_t to induce stationarity. The de-trended versions of the respective variables are defined as follows:

$$\widehat{C}_t \equiv \frac{C_t}{\Gamma_t}, \widehat{Y}_t \equiv \frac{Y_t}{\Gamma_t}, \widehat{I}_t \equiv \frac{I_t}{\Gamma_t}, \widehat{K}_{t+1} \equiv \frac{K_{t+1}}{\Gamma_t}, \widehat{W}_t \equiv \frac{W_t}{\Gamma_t}.$$

We have the following equilibrium conditions which characterized this economy:

Cobb-Douglas production function:

$$\widehat{Y}_t = e^{z_t} \widehat{K}_{t-1}^{1-\alpha} H_t^\alpha g_t^{-1}, \quad (10)$$

Labour demand:

$$\widehat{W}_t = \alpha \widehat{Y}_t / H_t,$$

Demand for capital:

$$R_t^K = (1 - \alpha) \widehat{Y}_t / \widehat{K}_{t-1} g_t^{-1},$$

Labour supply:

$$(1 - \psi) \widehat{C}_t = \psi (1 - H_t) \widehat{W}_t,$$

Euler for capital:

$$\widehat{C}_t^{\psi(1-\sigma)-1} (1 - H_t)^{(1-\psi)(1-\sigma)} = \beta g_{t+1}^{\psi(1-\sigma)-1}$$

$$\widehat{C}_{t+1}^{\psi(1-\sigma)-1} (1 - H_{t+1})^{(1-\psi)(1-\sigma)} (1 + R_{t+1} - \delta),$$

Law of motion for capital:

$$\widehat{K}_t = (1 - \delta) \widehat{K}_{t-1} g_t^{-1} + \widehat{I}_t,$$

Aggregate resource constraints:

$$\widehat{C}_t + \widehat{K}_t = \widehat{Y}_t + (1 - \delta) \widehat{K}_{t-1} g_t^{-1},$$

$$\widehat{Y}_t = \widehat{C}_t + \widehat{I}_t.$$

3.2. Extensions

It is well known in the early moment matching exercises where the standard RBC model are incapable of replicating the second moments of labour market dynamics.¹³ Hence, different extensions to and modifications of the RBC model have been proposed by many

¹³ For details, see Hansen and Wright (1992) and Christiano and Eichenbaum (1992).

researchers. Following the literature we have built an augmented RBC model with capacity utilization, investment adjustment cost and indivisible labour with temporary and permanent productivity shocks to explain labour market facts observed in the data. The idea using these extensions is to show how far these models can take us in explaining labour market fluctuations of EMEs.

3.2.1. The RBC model with capacity utilization

The basic idea of using capacity utilization is that it allows capital to vary in response to productivity shocks in business cycle fluctuations by intensifying the capital while the capital enters for a predetermined period in the model. Hence, this mechanism substantially improves the ability of the model to account for the features of the data. Greenwood et al. (1988) suggest that a variable capacity utilization rate may be important for understanding of business cycles since it provides a channel through which shocks via their impact on capacity utilization can affect labour productivity and hence equilibrium employment. Moreover, Burnside and Eichenbaum (1994) study the role of capacity utilization in propagating shocks over the business cycle. They find that it magnifies and propagates the impact of the shock since it provides an additional margin to adjust the level of output (see also Cogley and Nason (1995) and Boileau and Normandin (1999)). Motivated by the findings in the literature, we hence examine the extent to which capacity utilization helps the RBC model match the labour market facts in EMEs. In this model, the law of motion for capital becomes

$$K_{t+1} = (1 - \delta X_t^\Omega) K_t + I_t, \quad (11)$$

X_t represents the capacity utilization rate, and the parameter Ω determines the intensity of capacity utilization. The term δX_t^Ω shows the capital depreciation rate, which depends on capital utilization, where δ is increasing and convex in X_t and $\Omega > 1$.

The production function depends on hours, the amount of capital and utilization as follows:

$$Y_t = e^{z_t} (K_t X_t)^{1-\alpha} (H_t \Gamma_t)^\alpha, \quad (12)$$

The term $K_t X_t$ represents capital services which depend on the production of utilization and the amount of physical capital. To understand the role of capacity utilization in amplifying and propagating business cycles in this model, it is useful to derive a reduced-form aggregate production function evaluated at the optimal rate of capacity utilization. The first order condition with respect to capacity utilization X_t is

$$(1 - \alpha) \frac{Y_t}{X_t} = \Omega \delta X_t^{\Omega-1} K_t. \quad (13)$$

Equation (13) shows that marginal output of an increase in the capacity utilization rate equals to the marginal change in capital depreciation rate due to the intensified usage of existing capital stock.

3.2.2. The RBC model with investment adjustment costs

The reason why we are interested in investment adjustment costs is that the standard RBC model causes a high volatility of investment since firms adjust their capital stock to the optimal level instantaneously. However, the incorporation of investment adjustment costs into the RBC model prevents investment quickly responding to changes in economic conditions. Furthermore, recent studies consider investment adjustment cost as a key mechanism that significantly improves the quantitative performance of the models along a number of dimensions. Burnside et al. (2004) find that these costs may explain the effects of a fiscal shock on hours

and wages. Moreover, [Albonico et al. \(2012\)](#) find that the RBC model with investment adjustment costs could resolve the productivity-hours puzzle and generate negative co-movements between hours and productivity.

We have the following properties as in [Christiano et al. \(2005\)](#) for the functional form of these costs. The law of motion for capital, with adjustment costs for investments, is given by

$$K_{t+1} = \left(1 - \frac{\varphi}{2} \left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) I_t + (1 - \delta)K_t, \quad (14)$$

The term $\frac{\varphi}{2} \left(\frac{I_t}{I_{t-1}} - 1\right)^2$ with $\varphi > 0$ captures the adjustment costs on investment I_t . It implies that there is a cost associated with changing the level of investment, that this cost is zero at steady state and that this cost is increasing in the change in investment. The Lagrangian multiplier for the model with investment adjustment costs is $q_t = \frac{\theta_t}{\lambda_t}$. We define Tobin's q_t as the shadow value of having an extra unit of capital, θ_t , and marginal utility of consumption, λ_t . If there are no adjustment costs, q_t equal to 1, that is the Tobin's marginal q_t should be equal to the replacement cost of installed capital in units of the final good. We do not present all of the stationarized equations since some of them are the same as in the basic RBC model. We have the following equilibrium conditions that characterize this economy Euler for capital:

$$\hat{q}_t = \beta \frac{\hat{\lambda}_{t+1}}{\hat{\lambda}_t} g_{t+1}^{-1} ((1 - \delta)q_{t+1} + R_{t+1}), \quad (15)$$

Euler for investment:

$$1 = \hat{q}_t \left(1 - \frac{\varphi}{2} \left(\frac{\hat{I}_t}{\hat{I}_{t-1}} g_t - 1\right)^2 - \varphi \left(\frac{\hat{I}_t}{\hat{I}_{t-1}} g_t - 1\right) \frac{\hat{I}_t}{\hat{I}_{t-1}} g_t\right) + \beta \hat{q}_{t+1} \frac{\hat{\lambda}_{t+1}}{\hat{\lambda}_t} g_{t+1}^{-1} \varphi \left(\frac{\hat{I}_{t+1}}{\hat{I}_t} g_{t+1} - 1\right), \left(\frac{\hat{I}_{t+1}}{\hat{I}_t} g_{t+1}\right)^2, \quad (16)$$

Law of motion for capital:

$$\hat{K}_t = \left(1 - \frac{\varphi}{2} \left(\frac{\hat{I}_t}{\hat{I}_{t-1}} g_t - 1\right)^2\right) \hat{I}_t + (1 - \delta)\hat{K}_{t-1} g_t^{-1}. \quad (17)$$

where q_t is the shadow price of capital in terms of consumption. Equation (17) is the present discounted value of having an additional unit of capital, measured in terms of its future value and the rental rate.

3.2.3. The RBC model with indivisible labour

[Hansen \(1985\)](#) emphasizes that fluctuations in hours worked in the real world come from the changes in both the extensive and intensive margins. His findings about the US, which revealed that most of the fluctuations in hours are mainly due to variations in the extensive margin (i.e., the employment rate), support the modelling of the RBC model with indivisible labour. In this study, the adoption of the indivisible model is very close to the EMEs experience. As reported in previous sections, fluctuations of the extensive margin are mostly responsible for fluctuations in the total hours worked in these economies rather than fluctuations in the intensive margin. In this model, utility is linear in h_t , and the inter-temporal elasticity of substitution is infinite for households. Thereby, labour supply varies to a greater extent inter-temporally in this economy. The utility function is given by

$$U(c_t, h_t) = \ln(c_t) + A \ln(1 - h_t), \quad (18)$$

A describes the weight on leisure in the utility function. Households uniformly have the same probability of working as they are identical in terms of skills and productivity. Thus,

$$U(c_t, h_t) = \ln(c_t) + A[\pi_t \ln(1 - h_0) + (1 - \pi_t) \ln(1)],$$

$$U(c_t, h_t) = \ln(c_t) + A\pi_t \ln(1 - h_0),$$

where h_t represents hours worked *per capita*. Indivisible labour is modelled by restricting the consumption possibilities set so that households work h_0 with a probability of π_t and the rest work zero (i.e., there is an employment lottery). This is given by

$$h_t = \pi_t h_0, \quad (19)$$

Preferences can be written as

$$U = \ln(c_t) + A \frac{\ln(1 - h_0)}{h_0} h_t, \quad (20)$$

$$B = -A \frac{\ln(1 - h_0)}{h_0}, \quad (21)$$

B represents the dis-utility parameter of composite labour. Therefore, we can write it within the period utility function as

$$U(c_t, h_t) = \ln(c_t) - B h_t. \quad (22)$$

3.3. Parameterization

[Table 3](#) shows the list of parameters we parametrize in order for the model to match data. It is important to have a good understanding of rationale behind the selection of the particular parameter values in order to properly evaluate the fit of the model for EMEs. In this study, the parameter values are generally picked from the existing literature due to lack of quality data in estimating these values governing stochastic productivity processes, preferences, production and adjustment costs in these countries. Therefore, we have relied on highly conventional parameters widely used in the DSGE models of annual frequency for the US. More specifically, the model is calibrated to match annual frequency and these values are fit for emerging countries.

The labour share α is calibrated to match the capital share data. We hence set α in production to 0.68, which is a standard value for the long run labour share income so that the value of capital share is set to 1/3 to match the average fraction of total income going to capital in EMEs. The discount factor β is calibrated to match the steady-state capital-output ratio in the capital Euler equation to that in data. The value of β used in literature ranges from 0.92 to 0.99 for annual frequency for emerging countries. We set this value to 0.95, in order to imply a steady-state real interest rate at about 5% per year, which is a value compatible with the observed interest rate face by emerging countries.¹⁴

We set the inverse of the Frisch elasticity of the labour supply ψ of the utility function to 0.33 so that it matches the steady state labour input level in the labour first order condition to that in data which is commonly used in the RBC literature. The value of the depreciation rate δ ranges from 0.03 to 0.12 per year for EMEs in the

¹⁴ However, [Garcia-Cicco et al. \(2010\)](#) set the parameter β to 0.92, which implies a relatively high average real interest rate of about 8.5 percent annually. They also explained that this value is empirically plausible for emerging market like Argentina.

Table 3
Parameters values in models.

Parameters	Definition	Value
β	The Discount factor	0.95
ψ	The inverse of the Frisch elas. of labour supply	0.33
α	The labour share of output	0.68
σ	The inter-temporal elasticity of subs. for consumption	2
δ	The depreciation rate of capital	0.07
μ_g	The productivity's mean growth rate	$\log(1.0066)$
ρ_z	The persistence of transitory shocks	0.6
ρ_g	The persistence of growth shock	0.01
φ	The adjustment cost on investment	4

Table 4
Business cycle moments.

	Data	USA	Model1	Model2	Model3	Model4	Model5	Model6	Model7
$\sigma(h)/\sigma(y)$	0.64	0.89	0.54	0.51	0.65	0.60	0.63	0.63	0.72
$\sigma(w)/\sigma(y)$	1.58	0.77	0.60	0.64	0.45	0.50	1.02	1.03	0.51
$\sigma(p)/\sigma(y)$	0.81	0.42	0.60	0.64	0.45	0.50	1.02	1.03	0.51
$\rho(y)$	0.63	0.55	0.36	0.37	0.35	0.36	0.32	0.32	0.36
$\rho(y, h)$	0.56	0.90	0.86	0.83	0.94	0.94	0.57	0.56	0.87
$\rho(y, w)$	0.39	0.54	0.89	0.90	0.87	0.90	0.99	1.00	0.73
$\rho(y, p)$	0.71	0.47	0.89	0.90	0.87	0.90	0.99	1.00	0.73

Note: σ represents relative volatility with the output and ρ represents the correlation with output. The terms h , y , w , and p stand for hours, output, wages and productivity, respectively. The first column of the table reports the results for the data moments on average for emerging countries and the second column presents the moments of US data for business cycle frequencies between 1970 and 2013. In the following columns, Model 1, Model 3 and Model 5 show the moments of our benchmark model, the model augmented capacity utilization and investment adjustment costs with the non-separable utility function, respectively. Model 2, Model 4 and Model 6 represent the results of these models associated with the separable utility function. Lastly, Model 7 shows the performance of the RBC model with indivisible labour.

literature. We have used a 7% annual depreciation rate to match the capital law of motion as it falls almost in the middle of that range.¹⁵ Since we have a permanent shock in the model, we set the coefficient of relative risk aversion σ to 1 in the case of the separable utility function in order to have a balanced growth path. However, we set the inverse of the inter-temporal elasticity of substitution to 2 which ranges from 1 to 2 in the case of the non-separable utility function in the standard business cycle literature.¹⁶ We set the investment adjustment cost parameter, φ , to 4 following [Albonico et al. \(2012\)](#).¹⁷

We used the five parameters to define the stochastic processes of the productivity shocks, g , ρ_z , ρ_g , ε_g , ε_z . The persistence value of the temporary shock, ρ_z , is set to 0.6 and the persistence of the permanent shock, ρ_g , is set to 0.01.¹⁸ Then we set the long-run productivity growth, μ_g , to $\log(1.0066)$ as in [Aguiar and Gopinath \(2007\)](#), who calibrate this value based on the average growth factor of the Mexican economy in their data. The standard deviation of the temporary shock, ε_z , and the permanent shock, ε_g , are normalized to 1%, which is compatible with the commonly used values in literature. In the next section, we first present the results based on our baseline parameter values in [Table 4](#). Then we discuss the sensitivity of our results, in light of the different parameter values used in other studies.

4. Results

The aim of this section is to show how the RBC models fit the features of the data for emerging countries and the US. The model we built generates data de-trended by the stochastic trend therefore, we have to obtain the level by adding back the permanent shock. We then log and de-trend this data as well using HP filter so that we can compare properly the data and the model moments. Note that [Table 4](#) shows the marginal and average productivity of labour are proportional to each other; therefore, the moments of the model for productivity and wages are the same.

The results for the standard RBC model are presented in column 3 and corresponds to the case in which we introduce only permanent and temporary productivity shocks. It can be seen that this model does a fairly good job of matching the relative volatility of hours, but it does not generate enough volatility of productivity and especially wages for these economies since the volatility of wages relative to output is much higher in the data than in the model. In addition, the model produces a positive and significant correlation for hours worked, wages and productivity with output, which are at odds with the data for EMEs. Moreover, this model replicates satisfactorily the correlation between hours and output for the US but it fails to capture the rest of the moments although the results are slightly better for this country compared to emerging economies.

The standard RBC model fails to account for many features of the data as it does not embody quantitatively important propagation mechanism. Model 3 introduces the capacity utilization in propagating shocks over the business cycle to the standard RBC model. In this model, we assume that the production function depends on labour, the amount of capital available and its utilization so capacity utilization alters the equilibrium production function as it amplifies the shocks. If capacity utilization does not vary much, it may be possible to increase the impact of shocks on hours worked and hence decrease labour productivity and real wages. As intuition would suggest we see that this model increases the relative

¹⁵ [Li \(2011\)](#) have set the depreciation rate to 3% while [Garcia-Cicco et al. \(2010\)](#) have set this value to 12% for annual frequency.

¹⁶ As in [Li \(2011\)](#), She calculates the σ based on data from Mexico.

¹⁷ They use the values between 0 and 20 for the investment adjustment cost.

¹⁸ The persistence of the permanent shock, ρ_g is taken from [Aguiar and Gopinath \(2007\)](#). They set the persistence value of the temporary shock, ρ_z as 0.95. The reason why we choose the lower value for ρ_z is that we use annual data but they use quarterly data. The persistence of the temporary shocks with annual data should be lower than quarterly data.

volatility of hours worked from 0.54 to 0.65 so that it now matches perfectly in explaining hours volatility for emerging countries. In addition, capacity utilization decreases significantly the abilities of the model to replicate the relative volatility of wages and productivity for these economies, compared to the standard RBC model. The model also generates excessive contemporaneous correlation between hours and output as it fails to replicate the correlation between all labour market variables and output for these countries. Moreover, this model has a much better representation of the relative volatility of productivity for the US compared to the standard RBC model. We see that this modification is not sufficient to bring the model more in line with EMEs data.

Table 4 also presents the results of extending the standard model to include the investment adjustment costs. This mechanism into the RBC model prevents investment quickly responding to shocks as it mitigates the effect of shocks on capital stock. Therefore, hours worked fluctuate much more less than wages and productivity in this model compared to the standard model. This suggests that capital stock could not adjust instantly and therefore, neither could hours. The intuition behind this might be that the negative impact of adjustment costs on hours worked is amplified by the wealth effect in preferences as households increase their consumption and decrease their labour supply. It would seem that the model with investment adjustment costs does a slightly better job than the other models, especially for the correlation between hours and output for emerging economies as well as it improves significantly the abilities of the model to replicate the volatility of wages for these economies as it is still disappointing even though it increases the relative volatility of wages almost twice as much as the other models. Moreover, this model increases the relative volatility of productivity compared to the model with capacity utilization but it is still insufficient to match this fact.

Model 7 introduces the indivisible labour to the standard RBC model. In this model individuals are assigned to jobs randomly so this model generates a large inter-temporal substitution effect for the individuals. Hence, it raises the hours worked volatility and decreases the cyclicity of wages and then productivity for the same shocks, unlike the other models. In Table 4, it can be seen that it increases fairly the relative volatility of hours (0.72) but it still replicates this data fact for emerging countries. This model also decreases the correlation of wages and productivity with output, as the model with indivisible labour is a much better representation of the correlation between productivity and output for these economies compared to the previous models. Finally, output is persistent with an autocorrelation of around 0.35 in the models as this is driven mainly by the persistence coefficients of the shocks.

Fig. 1 shows the average contemporaneous, lead and lag correlation coefficients between the labour market variables from period $t - 4$ to $t + 4$ and the output for the actual data and the simulated data. We see that the cross-correlation of these variables exhibits a hump-like shape for both data but the model does not generate fairly the results as in the actual data. In particular, we figure out that hours worked, productivity and wages are pro-cyclical in the actual data as well as in the simulated data although the model seems to reproduce a higher contemporaneous correlation, leading the cycle by four years in both. In addition, the model produces higher correlation between hours and output until one lag but lower correlation for productivity and wages until four lags compared to the real data.

4.1. Sensitivity analysis

For sensitivity, we set the value of ρ_z in our benchmark model as in Aguiar and Gopinath (2007) as 0.95. The results show that the

volatility of hours (0.30) significantly decreases but the volatility of wages (0.80) increases so the persistence of temporary shocks matters how labour supply and demand react.¹⁹ Furthermore, we shut down the interaction between temporary shock and permanent shock in our baseline model, it means that ε_z or ε_g is equal to 0. The reason we do this is that if technology shocks affect wages through the marginal product of labour relationship, then this affects hours through labour supply, leading to labour market dynamics that will be different if the shocks are only temporary or if they are only growth shocks. When we shut down the temporary shock we find that there is a significant decrease in the volatility of hours worked (0.20). It under-predicts the performance of the model in terms of the matching hours worked volatility but improves the performance of the model in terms of productivity volatility (0.96) and wages volatility (0.96). It also raises the persistent of the output to 0.40. When we shut down the permanent shock, the model significantly under-predicts the volatility of wages (0.44) and there are not much significant changes in terms of the correlation of the variables compared to the standard RBC model.

We also check the results by altering the values of σ , φ and ψ while holding the other parameters constant. In the non-separable utility function the value of ψ is important because the steady state of hours has to be 1/3 but we can assign different values to σ . Thus, we set the value of σ to 0.99. Additionally, in the case with the separable utility function the value of σ has to be 1 for balanced growth but we could assign different values to ψ . Lastly, we set the adjustment cost to 2 as in line with Albonico et al. (2012)'s study. We discovered that our results are slightly different but it does not change the performance of our models to explain labour market facts for emerging countries. In addition, Table 4 shows that our results are not sensitive to differences in preferences used in the analysis.

Overall, as can be seen, these models are less than ideal for explaining the variability of wages in these countries but they do a fairly good job of matching the variability of hours. Moreover, the model with investment adjustment costs does a slightly better job than the other models, especially for the correlation between hours and output as well as the relative volatility of hours and wages, but it still does not perform so well in regard to the volatility of wages, even though it increases the relative volatility of wages almost twice as much as the other models. Since the results show some extreme values for real wages in the country level analysis in the data section, we exclude these extreme values from our analysis. We found a lower volatility of wages, at 1.24 compared to the average. Moreover, we took the median of our sample and found that the effect of the outliers is smaller (1.29) compared to the average. We then compare our models' moments with those for which we drop the extreme observations and calculate the medians. We find that our models do a better job of explaining only the high volatility of wages in these economies.

5. The labour wedge

In this section we analyse the labour wedge which measures the degree of inefficiency in the labour market for business cycles in EMEs and the US. The purpose of looking at labour wedge in this paper is to give insight into the labour market frictions or distortions to account for the business cycles in EMEs and provides a useful guide for researchers about where to introduce frictions into their models. We look at it through the lens of a standard RBC

¹⁹ When we change the persistence of permanent shocks (as 0.1), we almost obtain the similar results with our benchmark model.



Fig. 1. Contemporaneous, lead and lag correlation coefficients between labour market variables and output.

model on the labour market. From the set-up of the model we know that the household's first order condition which measures the marginal rate of substitution (MRS), is equal to wages (w) and the firm's first order condition which measures the marginal product of labour (MPL) is also equal to wages (w). Thus, the optimal choice of hours is determined in equilibrium such that the MRS and MPL are equal to each other. However, this condition is violated empirically, and that the labour wedge, defined as a gap between these two objects, is characterized by large cyclical variations.

In the recent years, many researchers have shown great interest in the behaviour of labour wedge at business cycle frequency. Chari et al. (2007) have pointed out that large cyclical changes in the relationship between the MRS and MPL as an important feature of business cycles. They find that it accounts for 60% of output fluctuations in the US, putting it at the center of their business cycle accounting research.²⁰ Moreover, Lama (2011) finds that labour wedge is important in accounting for output drops in Argentina, Brazil, Chile, Colombia, Mexico and Peru as Simonovska and Soderling (2015) shows that the labour wedge is one of the most important wedges responsible for business cycle changes in Chile.

Given the relevance of the topic we are interested in exploring whether the fluctuations in the labour wedge come mostly from the household component or the firm component of the labour wedge in the emerging countries and the US. Such analysis is important to understand whether frictions at the firm level or the household level are relatively more important in these economies for building a successful model of the business cycle. For this analysis, using the methodology proposed by Karabarounis (2014),²¹ we decompose the labour wedge into a gap between the MPL and the real wage (the firm component of the labour wedge) and into a gap between the real wage and the MRS (the household component of the labour wedge):

$$\begin{aligned} \exp(-\tau_t^f) \text{MPL}_t &= w_t, \\ \exp(\tau_t^h) \text{MRS}_t &= w_t, \end{aligned} \quad (23)$$

where τ_t^f denotes the firm component of the labour wedge, and τ_t^h denotes the household component. The total labour wedge, τ_t is defined as the gap between the MPL and the MRS:

$$\tau_t = \log(\text{MPL}_t) - \log(\text{MRS}_t) = \tau_t^f + \tau_t^h. \quad (24)$$

Table 5 shows the cyclical properties of the firm and household components of the labour wedge and of the total labour wedge with output between 1970 and 2013 for these economies. We find that total labour wedge (relative to output volatility) is more volatile in emerging countries (1.72) than in the US (0.95). These results show that the degree of labour market distortions is higher in EMEs compared to the US. In particular the relative volatility of the household component (2.09) and the firm component (1.24) of the labour wedge in emerging countries is 2–3 times higher than the same components in the US.

We also found that the wedge in the US moves counter-cyclically to output; however, for emerging countries we obtain heterogeneous results. For example: the total labour wedge moves cyclically to output in Costa Rica and Peru while it moves counter-cyclically in Colombia, Jamaica, Mexico, and Hungary. In the literature many factors have been highlighted behind the cyclical behaviour of the labour wedge which comes from not only by labour market frictions, but also by product market imperfections such as distortionary taxes and subsidies, presence of rigidities and informal sector, unemployment benefits, and social security system. The heterogeneous cyclicity of the labour wedge shows that labour and product market distortions that affect labour wedge are different among EMEs. When we compare our results with those of Karabarounis (2014)'s work for the US, we find our results to be slightly different, especially for the correlation between the firm component of the labour wedge and output. We obtain a negative value for this, while he finds a positive value. This could be because

²⁰ Also, Shimer (2009) and Ohanian and Raffo (2012) focus on the behaviour of the labour wedge at business cycle frequency.

²¹ We follow this paper setting discretionary time available work and leisure equal to 92 h per week per person.

Table 5
The cyclical properties of the firm and household components of the labour wedge in emerging countries and USA.

Countries	$\frac{\sigma(\tau^f)}{\sigma(y)}$	$\frac{\sigma(\tau^h)}{\sigma(y)}$	$\frac{\sigma(\tau^T)}{\sigma(y)}$	$\rho(y, \tau^f)$	$\rho(y, \tau^h)$	$\rho(y, \tau^T)$
Brazil	2.10	2.21	0.93	-0.50	0.45	-0.05
Bulgaria	1.17	2.22	1.84	0.10	-0.31	-0.31
Chile	1.14	1.72	1.17	-0.37	0.21	-0.05
Colombia	1.06	2.13	1.72	0.19	-0.48	-0.48
Costa Rica	1.10	1.73	1.89	0.17	0.19	0.28
Czech Republic	0.55	1.72	0.50	-0.002	-0.20	-0.23
Estonia	0.75	1.77	1.88	-0.05	-0.16	-0.17
Hungary	1.02	1.32	1.51	-0.29	-0.06	-0.25
Jamaica	0.98	2.60	2.64	-0.45	-0.55	-0.71
Mexico	1.86	2.13	1.00	-0.48	0.34	-0.17
Peru	1.81	2.13	1.14	-0.51	0.62	0.33
Slovenia	0.67	1.43	1.26	0.58	-0.46	-0.22
South Korea	1.47	2.72	2.55	-0.30	0.10	-0.07
Thailand	0.65	1.53	1.50	-0.30	0.15	0.02
Turkey	2.40	2.41	0.98	-0.07	0.04	-0.06
Average	1.24	2.09	1.72	-0.14	0.004	-0.12
USA	0.52	0.82	0.95	-0.38	-0.74	-0.85

Note: $\sigma(\tau^f)$, $\sigma(\tau^h)$, $\sigma(\tau^T)$ show the standard deviation of the firm component, the household component and the total labour wedge, respectively, relative to the standard deviation of output. $\rho(\tau^f)$, $\rho(\tau^h)$, $\rho(\tau^T)$ show the correlations of these component with the output.

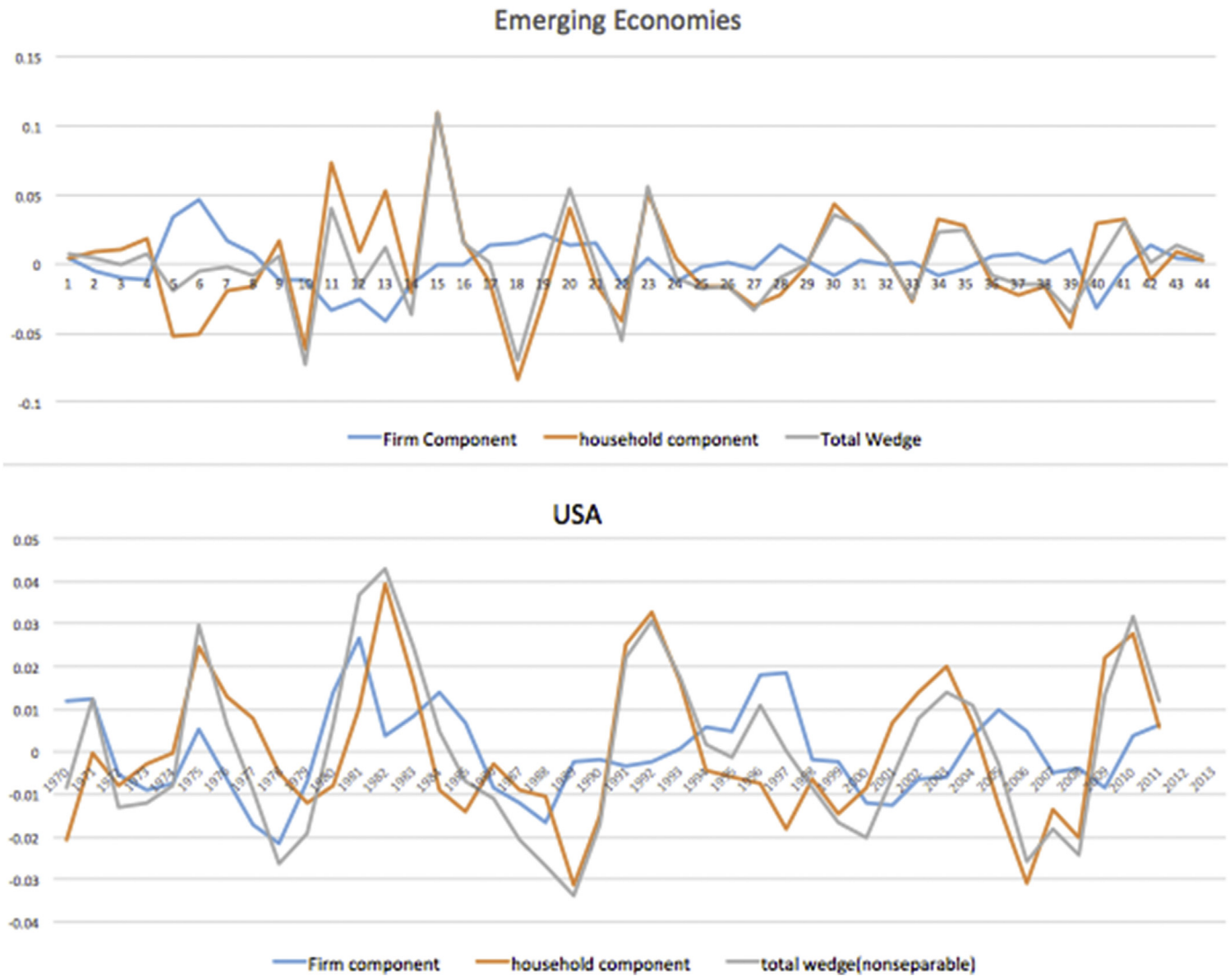


Fig. 2. The decomposition of the labour wedge - non-separable preference.

he uses quarterly data and adjusted wages for taxes but we use annual data and not tax-adjusted real wages.

Moreover, Fig. 2 shows that the fluctuations in the labour wedge predominantly reflect fluctuations in the gap between the real wage and the marginal rate of substitution for emerging economies and for the US. This implies that there is a strong relationship between the household component of the labour wedge and the overall labour wedge in both countries since the household component co-moves very closely with the total wedge. The standard business cycle model does not specify the underlying source of the labour wedge but we can conclude that researchers need to focus on frictions coming from the household component of wedge to better analyse the labour market fluctuations of business cycles in these economies as the model does badly on explaining hours and wages. This study could be a useful source to motivate future research on the topic for these economies. Lastly, we have figured out that our results are insensitive to the choice of preferences in our analysis.

6. Conclusion

In this study our aim was to show how far the various RBC models with permanent and transitory productivity shocks could take us in explaining the labour market fluctuations of business cycles in emerging countries, rather than to show a model that incorporates all extensions of the RBC could produce all labour market facts. Therefore, we first investigated labour market fluctuations in the business cycles of EMEs and compared these results with findings from the US for the period of 1970–2013. In the data we observed that the behaviour of labour market variables are not uniform across countries. Compared to the US, we found that on average real wages and productivity are very volatile but less volatile in terms of the quantities in the emerging countries.

Furthermore, we evaluated the performance of a standard RBC model in explaining labour market fluctuations in emerging countries. The simulation results show that the standard RBC model does reasonably well in matching the relative volatility of the hours worked in EMEs; however, it fails to account for the rest of the relevant moments in our analysis. In order to further improve the fit we introduce an RBC model augmented with real frictions. We found that each of these extensions improved the capability of the RBC model by manipulating a different economic dimension. Especially the model with investment adjustment cost improved the performance of the model in regard to the relative volatility of wages and hours, as well as the cyclical nature of hours, compared to the standard RBC model for these countries. Lastly we investigated the cyclical behaviour of the labour wedge. We found that the labour wedge is more volatile in EMEs than in the US and the fluctuations in the labour wedge are mostly driven by fluctuations in the gap between the real wage and the MRS in both emerging countries and the US. This study is helpful in revealing shortcomings of these models for EMEs and shows which directions the model needs to be modified to make it more consistent with the data.

Appendix

7.1. The Standard RBC Model

For non-separable utility function, the first-order conditions of consumption, hours and capital are respectively given by:

$$\begin{aligned}\lambda_t &= \psi C_t^{\psi(1-\sigma)-1} (1 - H_t)^{(1-\psi)(1-\sigma)} \\ (1 - \psi)C_t &= \psi(1 - H_t)W_t \\ \lambda_t &= \beta\lambda_{t+1}(1 + R_{t+1} - \delta)\end{aligned}\quad (25)$$

Since all the variables in (12) are stationary, we can compute a steady state, dropping time subscripts

$$\begin{aligned}\widehat{Y} &= \widehat{K}^{1-\alpha} H^\alpha \mu_g^{\alpha-1} \\ \widehat{W} &= \alpha \widehat{Y} / H \\ \widehat{R} &= (1 - \alpha) \widehat{Y} / \widehat{K} \mu_g^{-1} \\ (1 - \psi) \widehat{C} &= \psi(1 - H) \widehat{W} \\ 1 &= \beta \mu_g^{\psi(1-\sigma)-1} (1 + R - \delta) \\ \widehat{C} + \widehat{K} &= \widehat{Y} + (1 - \delta) \widehat{K} \mu_g^{-1} \\ \widehat{K} &= (1 - \delta) \widehat{K} \mu_g^{-1} + \widehat{I} \\ \widehat{Y} &= \widehat{C} + \widehat{I}\end{aligned}\quad (26)$$

Then, here is the solution for the steady state of the model:

$$\begin{aligned}R &= \frac{1}{\beta \mu_g^{\psi(1-\sigma)-1}} - (1 - \delta) \\ \frac{Y}{K} &= \frac{R}{(1 - \alpha) \mu_g} \\ \frac{I}{Y} &= \frac{K}{Y} \left(1 - (1 - \delta) \right) \mu_g^{-1} \\ \frac{C}{Y} &= 1 - \frac{I}{Y} \\ H &= \left(\frac{1 - \psi}{\psi \alpha} \frac{C}{Y} + 1 \right)^{-1} \\ K &= \left(\frac{H^\alpha \mu_g^{\alpha-1}}{\frac{Y}{K}} \right)^{\frac{1}{\alpha}} \\ Y &= K^{1-\alpha} H^\alpha \mu_g^{\alpha-1} \\ C &= \frac{C}{Y} Y \\ I &= \frac{I}{Y} Y \\ W &= \alpha \frac{Y}{H}\end{aligned}\quad (27)$$

For the separable utility function σ equals 1 in order to hold the balance of growth in the long run. For households the first-order conditions of consumption, hours and capital are given by

$$\begin{aligned}\lambda_t &= C_t^{-1}, \\ \chi H_t^\psi &= C_t^{-1} W_t \\ \lambda_t &= \beta \lambda_{t+1} (1 + R_{t+1} - \delta)\end{aligned}\quad (28)$$

respectively. We set the steady state of hours to 1 in order to find the value of χ in the steady state. The solution for the steady state for the separable utility function is

$$\begin{aligned}R &= \frac{1}{\beta \mu_g^{-1}} - (1 - \delta) \\ H &= 1 \\ \chi &= C^{-1} W\end{aligned}\quad (29)$$

The rest of the steady-state solutions for the variables are the

same for the RBC model with the non-separable utility function.

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