Bi-Demographic and Current Account Dynamics using SVAR Model: Evidence from Saudi Arabia

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Abstract

The study explores the impacts of the bi-demographic structure on the current account and gross domestic product (GDP) growth. Using structural vector autoregressive modeling (SVAR), we track the dynamic impacts on these underlying variables. New insights about the dynamic interrelation between bi-population age dependency rate, current account, and GDP growth have been developed. In the short and medium-term, the reactions of GDP growth to both shocks of native and immigrant working-age populations move unsteadily in opposite directions. However, in the long-run, both effects become moderately positive. Additionally, the positive long-run contribution of immigrant workers to the current account growth largely compensates for the negative contribution of the native population. We find a negative hump-shaped reaction of Saudi Age Dependency Rate to immigration policy shocks during a generation. When the shocks emanate from immigrants' working age, there is a complex mechanism from the complementarity process to the substitutability process between immigrants and the Saudi workforce. In the short and medium-term, the immigrant workers are more complements than substitutes for native workers.

Keywords. Native population, Immigrant population, Current account, Economic Growth, Structural VAR.
JEL Class. C51, F22, F41, J15, J23.

Highlights

- Exploring the impacts of bi-demographic structure on current account and GDP growth
- New insights on the interrelations between bi-population, CA and GDP growth
- The demand labor for immigrants has a positive long-run impact on GDP growth
- The immigrants are more complements than substitutes for native workers

1. Introduction

Macroeconomic literature has regained increasing interest among economists analyzing the effects of demographic structures on the current account. This issue is important as all economies deal with the consequences of the aging population. According to the life-cycle hypothesis (LCH), people in working-age consume a smaller fraction of their current income than younger and older people. Dynan et al. (2009) find that the middle-aged household-group tends to save relatively more than other age-groups, while the young and old-aged households tend to dissave. The current account balance (CAB) shows the interactions between consumption and investment behaviors during the life-cycle paths of all groups of the population. Consequently, the CAB is affected by demographic change and population structure. According to the literature survey of Hassan et al. (2011), when the LCH is extended to open economies, it implies that age structure affects the CAB, positively affecting the working-age population and negatively affecting the young dependent population. They indicate a lack of a theoretical model in this area of research. We consider that the impact of hybrid demographic structure on the current account has not yet been explored in related literature.

This paper explores the impacts of bi-demographic structure on the current account by splitting the population into natives and immigrants.[1,2] By considering the dataset of Saudi Arabia's economy empirically, we find that a positive shock of native active age ratio contributes positively to the CAB.[3] By compiling demand labor for immigrant and native working-age population shocks, we detect that the effect on the current account depends on their interactions over the time horizon. According to our findings, the immigrants appear to be for natives i.e. Saudi workers complement more than they substitute. This could help to improve the social and economic visibility of the decision-makers in different ministries and public institutions, including many departments of research and studies.

In Section 2 we review the literature related mostly to the relationship between demographic changes and CAB. Section 3 displays the demographic and economic stylized facts of Saudi Arabia. Section 4 displays the time series of the empirical model and its estimation. The results are discussed in Section 5 and we conclude in Section 6.

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[1] The term immigrant is more appropriate in our case since the vast majority of foreign people has restricted visas and are connected to the persons or companies where they work through a sponsorship system (named Kafala i.e. cautioner system).
[2] The term of bi-demographic structure is justified by the wide size of the immigrant to the native population. In 2016, the immigrant working-age population was about 8.8 million and the native active population reached 9.4 million.
[3] The dependency rate refers to the ratio of children (below 25 years) and old aged (above 65 years) to the working age population (from 25 to 65 years). We can use the active age structure ratio which is the inverse of the age-dependency rate as in Fair and Dominguez (1991).

2. Literature review

Using the LCH approach, pioneering articles investigate the relationship between dependency rate and CAB, such as Taylor and Williamson (1994), Taylor (1995), Higgins (1998), Kim and Lee (2008). In a partial equilibrium approach, Taylor and Williamson (1994) assume a full pass-through of surplus savings into the current account and then overestimate the impact of dependency rate on CAB. Additionally, by exploring the Latin American savings and investment behaviors during the first decades of the 20th century, Taylor (1995) determines their implications on the CABs. By identifying a significant statistical relationship between demographic structure and the current account-to-GDP ratio, Taylor expects that demographic changes in Latin American region could reduce its current account deficit by encouraging savings processes during mid-life years. Higgins (1998) explores the relationship between age structures, saving, investment, and CAB using a panel of 100 countries. He highlights that a lower dependency rate could imply a current account surplus. Kim and Lee (2008) consider the effects of demographic change on the CAB of the G7 countries using panel vector autoregressive (VAR) modeling. They find that increasing dependency rates deteriorate the CAB. An increasing rate of the aging population might cause a decline in saving rates and leads to CAB deterioration. Recently, by using the LCH, Gudmundsson and Zoega (2014) explore the effects of population age structure on the current account imbalances for 57 countries over 2005-2009. They indicate significant effects of age structure on the CABs.

The overlapping generations (OLG) approach, instead of LCH, is used by many research studies such as Brooks (2000), Feroli (2006), Karras (2009), and Marchiori (2011).[4] Brooks (2000) indicates that the differences in cohort population growth worldwide determine the CAB and the international capital flows. He finds that globally falling (rising) in cohort population growth would generate current account surplus (deficit) and capital outflow (inflow). Feroli (2006) indicates that demographic changes may play a significant role in determining the size of the US current account deficits, but he considers this issue to be a puzzle. Karras (2009) finds that when the national savings rate decreases, the link between population growth and CAB is ambiguous. Without considering age dependency rates, he emphasizes that such links depend on the size of the public sector and can be explained by the discrepancies between saving rate and investment rate. Marchiori (2011) examines the impact of demographic changes on international capital flows and current accounts, and its results are consistent with the LCH.

[4] The overlapping generations framework supposes that the representative agent lives for four periods: childhood, young working age, old working age and retirement.

According to the literature review, there is no consensus about the impacts of age structure on the current account. The difference between economies of such impacts depends on the agents' preferences and behaviors during the time horizon. For instance, the findings of Kim and Lee (2008) indicate that there is a negative empirical relationship between demographic dependency rates and CAB. Still, such a link is valid conditionally to a decline in saving rates.

Moreover, when the economy requires a more active native population with some specific skills that could not be satisfied in the short-term, international immigration could lead to the adjustment of the disequilibrium in the domestic labor market (Dustmann et al. 2005). The intensity of the demand for immigrant workers by private and public sectors depends on the magnitude of the domestic labor market imbalances. The common analysis of previous literature can be extended to explore the effects of bi-cohort active population growth on CAB. However, there is no research paper addressing the demographic effects of native and immigrant age structure on the CAB as far as we know. This study contributes to filling this gap using a SVAR approach by exploring the impacts and shocks of the native and immigrant dependency rates on the CAB.

3. Eco-demographic stylized facts and Data of Saudi Arabia

3.1 Eco-demographic stylized facts

The increasing number of immigrants has transformed the age pyramid of many gulf cooperation council (GCC) countries, as in Saudi Arabia. Such substantial demographic change leads to a population structure qualified as a bi-population (native and immigrant). According to the Saudi official five censuses data from census 1974 to census 2016,[5] the proportion of immigrants in the 25-64 working age is more important than its corresponding Saudi working age. However, it shows a negative trend from 1998 (Appendix 2, Figures A).

The correlation between economic variables and the changes in demographic age structure is scarcely used in empirical studies. Nevertheless, some empirical works about Saudi Arabia's economy consider the effects of demographic variables. For instance, in the long-run, Hasanov (2019) finds that the working age of the entire population has a greater effect on the Saudi industrial electricity consumption

[5] The first official population census of Saudi Arabia was in 1974, this explains the starting year of our dataset. During the period 1974–2016, there are many events and stylized facts that impacted and continue to impact the economic and demographic factors. First, the revenues from oil exports are the major financial sources of Saudi Arabia economy, such returns affect the CAB. Consequently, any perturbation in oil revenues leads to multiple shocks. Also, the reliance on foreign demand and foreign supply labor make the Saudi economy vulnerable to any international or regional or local crisis as the international financial crisis, regional wars, progressive changes in behaviors, and demographic changes in terms of ages or immigrant flows.

than economic variables. Additionally, Asharaf and Mouselhy (2013) document that the aging phenomenon occurs only in the native population and that the slow shift in age structure is due to the influx of immigrants.

By considering the correlation between CA-to-GDP (CAY) ratio and bi-population age structure as outlined in Figure 1, the findings indicate that Saudis young age of 0-24 is negatively correlated to CAY (-0.348 with p-value 0.011).[6] While both Saudis old 65+ age and Saudis working 25-64 ages are positively correlated to CAY, the results are 0.316 with a p-value 0.019 and 0.334 with p-value 0.014, respectively (Tables A, Appendix 1).[7] The sign of the correlation between Saudis 65+ old age and CAY does not corroborate with the conventional LCH. This result can be explained by the social organization related to religious culture and the Islamic belief of Saudi citizens who live in a common familial housing, and by the economic management dominated by the familial enterprises.

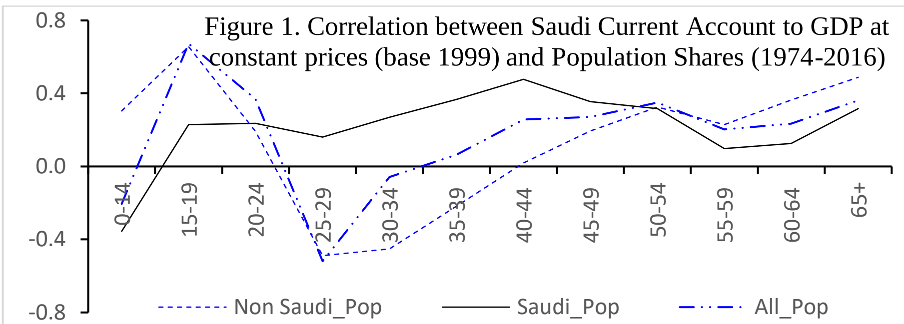
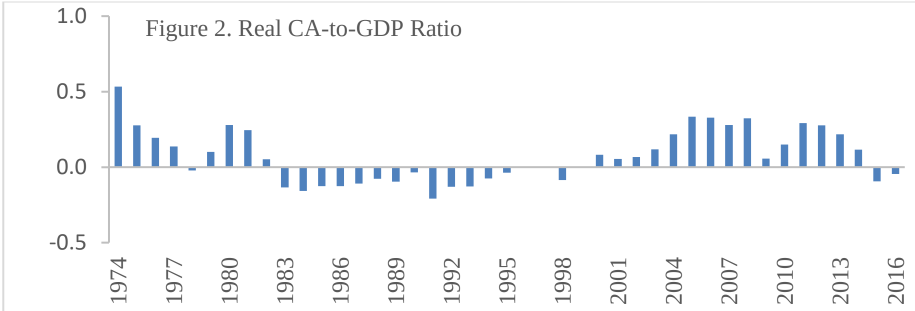


Figure 1. Correlation between Saudi Current Account to GDP at constant prices (base 1999) and Population Shares (1974-2016)

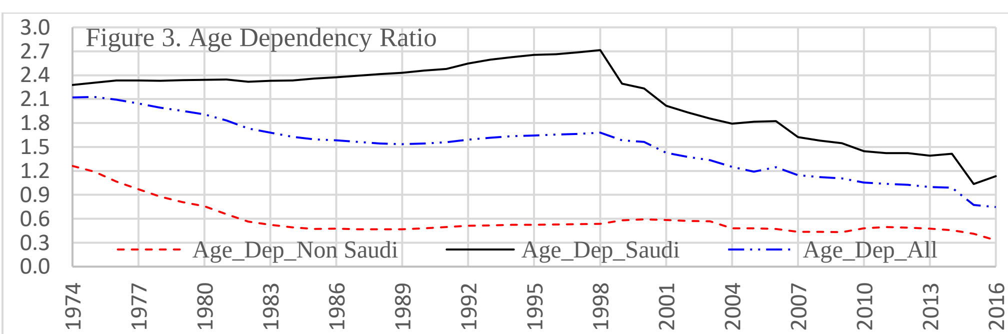
In contrast to Saudi working age, we find that the correlation between immigrant working age and CAY is negative (-0.394 with p-value 0.0045). There are two opposite cycles for the active age population in the nexus between CAB and population age structure by considering the bi-population data. Such explorative results can be explained as follows: as most immigrants keep their family members in their native countries and live alone in the host country, they remit a considerable share of their labor income to their offsprings and communities.[8] A preliminary analysis cannot capture the dynamic between economic and demographic variables. There is a need to treat the dynamic effects of the dual-age structure as bi-life cycle to detect their impacts on CABs (Figures 1 and 2).

[6] The sources of data are General Authority for Statistics (GaStat, Statistics library, https://www.stats.gov.sa/en), Saudi Monetary Authority (SAMA, Economic reports and statistics, http://www.sama.gov.sa/en-US/Pages/default.aspx).
[7] The proportion of age structure are calculated within each group of the citizens and immigrants.
[8] According to GaStat and the ministry of Labor (2015) and during the last decade 2005–2014, the immigrant labor force in the private sector reached in average 87%, and only 8% in the government sector.



The increase of remittance outflows would contribute to reducing (increasing) the current account surplus (deficit) of the host Saudi economy (host country), the world's largest source of immigrant worker remittances. The immigrants represent 58.2% of the native population (Census 2016), but their remittance outflows to GDP ratio are only about 5.8% (World Bank Group, 2016).[9] The immigrants are mostly low-to-medium-skilled labor, leading to low wages. Due to their large proportion in the total workforce and economic contribution, the immigrant workers generate more net earnings for the employers. This interpretation is confirmed by the theoretical illustration of Borjas (2019) by using the concept of immigration surplus.

The main component of the immigrants in the working-age affects the CAB negatively through the remittances. However, the added value generated by the immigrants' contribution to the economic activities would be profitable for the host economy (Ortega and Peri 2009, Peri 2016). In the long-run, considering the immigrants' rationale, there is a bi-life-cycle hypothesis (bi-LCH) that can hold in the Saudi economy. As indicated by Castles and Miller (2009), Naufal and Genc (2012) and Amuedo-Dorantes (2014), the remittances are driven by several motives, essentially social reasons. The remittances and their impacts on the current account remain understudied in the economic literature. We consider that the remittances are affected by the variability across economic ups and downs in the host and home economies and their effects remain an empirical challenge.



[9] For more details see the links: https://www.worldbank.org/en/topic/labormarkets/brief/migration-and-remittances or https://www.knomad.org/data/remittances

Figure 3 shows that even if the Saudi age dependency ratio (ADR) has decreased since 1998, it is still greater than one. This means that the native worker population still has to support the economic life of the dependents young and older population. By considering the immigrant population and immigrant workers, the total ADR appears inferior to the Saudi ADR. Since 2013, the total ADR has become less than one, and economically desirable situation.[10] As indicated by Simon et al. (2012), the age-specific immigration profile would reduce the ADR. However, the total ADR is still higher by 75% in 2016. We expect that economies with a decreasing dependency rate and considerable natural resources may generate current account surpluses.

In Saudi Arabia, there is a dual labor market in both public and private sectors where the Saudi jobs have mostly high wages, but the non-Saudi jobs have lower wages typically.[11] By eliminating such duality, connecting wages to productivity, and socially-integrated selectively the families of workers, the remittance processes would be reduced or even reversed.

3.2 Data, primary tests and bounds cointegration test

3.2.1 Data and primary tests

To examine the interactions between bi-population changes and CAB, we use the variables, current account to GDP (CA-to-GDP), bi-age-dependency rate (ADRs for Saudi, immigrant and all population) and growth of real GDP (g_{GDP}). The period of observations is 1974–2016, where the data are sourced and obtained from the GaStat. In Saudi Arabia, the reliability of the statistical data began from the years 1970, but the first official population census was in 1974. We have started this research in 2018, and the available dataset was until 2016. There are many events and stylized facts (see Section 3.1) that impacted the economic and demographic variables of Saudi Arabia. First of all, the revenues from oil exports are the major financial sources of Saudi Arabia economy, such returns affect the current account balance. Any perturbation in oil revenues constitutes a shock in the Saudi Arabia economy. Also, the reliance on foreign demand and foreign supply labor makes the Saudi economy vulnerable to any international or regional or local crisis as the international financial crisis, regional wars, progressive changes in the behaviors, and demographic changes in terms of ages and immigrant flows.

[10] Following the GaStat (Demographic Survey 2016), we define the immigrant age-dependency rate by considering the immigrant residents in Saudi Arabia.
[11] According to the Saudi Ministry of Labor (Labor market report July 2016, page 15), most immigrant workers are low-skilled and habitually employed with low wages in construction, retail and wholesale trade, personal services, and manufacturing.

The gathering of bi-demographic data by ages, for Saudi and non-Saudi, was very laborious; we used the official data from the census of 1974 to the census of 2016 that are available in different reports of General Authority for Statistics and Saudi Monetary Authority, in addition to the labor market reports of the Saudi Ministry of Labor (To save space, we have not displayed all the details of the dataset, but all data are available upon request). The Figures A of the bi-population pyramids visualize by census the determinant role of the working age immigrants in the dynamic of the active population in the entire Saudi economy (Appendix 2). The group of ages constructed are [0, 24], [25, 64], [65, +] for Saudi population, immigrant population, and all population as the sum of Saudi and non-Saudi populations. From the raw data, we focus in constructing the variables of age-dependency rates (ADR) by year for Saudis and immigrants; this ratio uses all group of ages. Involving all the components of population ages, the variable ADR is defined as the ratio between the groups of youth and old (0-24; 65+) and the age group 25-64 of working age (See Tables A, Appendix 1). It is constructed for Saudis, immigrants and all population, named s_ADR, ns_ADR, to_ADR, respectively. Its dynamic changes would influence the economic behaviors and then exercises many impacts on macroeconomic variables and particularly on the economic growth and current account as a global picture of the economy.

Firstly, we show the descriptive statistics of data in Table B (Appendix 1). Additionally, we explore the properties of the date-time series by testing for stationarity using Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992)[12] test, and the cointegrating regression models using Engle-Granger (EG, 1987), Hansen (1992), Park (1992), and Pesaran et al. (2001) tests.

We consider that KPSS test is a valuable tool when seeking the presence or absence of random walk in time series. As indicated by KPSS (1992), we use a reasonable large lag truncation parameter to reduce the autocorrelation effect. In running the KPSS test, we employ the quadratic spectral kernel that leads to a higher power in small samples (Hobijn, Franses and Ooms 2004), the Newey-West automatic bandwidth selection[13] (Kiefer and Vogelsang 2005), and without pre-whitening the underlying series using ARMA process. Using the latter test-option, we can reject the null hypothesis of level-stationarity for g_{GDP} and the null hypothesis of trend-stationarity for all the other series i.e. CA-to-GDP and ADR variables (Tables C, Appendix 1).

[12] Differently to ADF test, KPSS test can check for the stationarity in the presence of a deterministic trend. It is a one-sided test because the parameter value of null hypothesis of stationarity is for the variance of random walk. We also apply Zivot and Andrews (2002) test to consider the structural breaks in the series (see Table C.2, Appendix 1).

[13] This leads to a significant reduction in the size distortion of the test in the relevant case of a highly autoregressive process.

Next, we consider a long-run regression explaining the real CA-to-GDP (cay_t) by the economic growth (g_gdp_t) and age-dependency rates (s_adr_t, ns_adr_t) where s_adr_t and ns_adr_t stand for Saudi and non-Saudi age dependency rates, respectively. We check whether the residuals from long-run regression, which regresses CA-to-GDP on ADRs and GDP growth, are stationary or not by using the residual-based test of cointegration as Engle-Granger (EG) test and investigating the parameter stability of cointegrating regression by using the Hansen test (1990). This latter applies the fully modified estimator of Phillips and Hansen (1990). The outcome of the EG test, leading to $\tau = -2.91$ at p-value 0.487, accepts the null hypothesis of no cointegration; and the result of Hansen test, driving to $LM_c = 0.83$ at p-value 0.049, rejects the null hypothesis of cointegration. Therefore, there is no cointegration between the CA-to-GDP, Saudi-ADR, immigrant-ADRs and GDP growth. The absence of cointegration can be explained by the differences in the growth process of each series, the small sample size, and the non-linear relationship between the underlying series (Engle and Granger 1991). The absence of cointegration means that there will be no loss of information in the short-run dynamics by dropping the long-run dynamic between the variables. Consequently, it is suitable to estimate a Structural VAR model in the first differences instead of in levels. To check the robustness of such previous results about the cointegration, we use the bounds test of Pesaran et al. (PSS, 2001) in the next subsection.

3.2.2 Bounds cointegration tests

It is important to indicate that the PSS (2001) approach using the Auto-Regressive Distributed Lag (ARDL) cointegration offers five alternative interpretations of the conditional error correction (CEC) model, distinguished by whether deterministic terms are included into the error correction term (ECT).

According to Gregory et al. (1996), not finding evidence for a long-run relationship can be due to ignoring the break-points in the cointegration test, when there is evidence for the presence of such breaks. To avoid misleading results, we add the dummy variable D_t to take into account the effects of explanatory and predetermined variables on the CA-to-GDP; [14] these dummies are identified through the break points by using the Zivot-Andrew tests of unit root (Table C.2, Appendix 1).[15] Such procedure exhibit the notable

[14] PSS (2001) used dummy variables in their empirical work, they indicate that the inclusion of such variables does not affect the asymptotic associated critical values when the fraction of non-zero dummy variables tends to zero as the sample size increases. Nevertheless as in PSS (2001), the critical values are valid as even if the dummies appear in the CEC equation, but they are not in the levels-equation i.e. long-run relationship.

[15] Unfortunately and even if it allows for a maximum number of five breaks, we cannot apply the Bai and Perron (1998) test for multiple structural breaks dates selected endogenously, because it is not reliable for small sample size as it requires at least 100 observations.

and shocking events (as the oil price shocks, financial crises, political and war tensions), that could cause shifts in the variables involved.

We will consider the cases where the long-run relationship components of the CAB include an intercept (case 2) or trend (cases 4 and 5) because, from our sample, the CAB can be either positive or negative.[16] As in the literature of ARDL bounds cointegration test, the rationale behind the choice of the case 4 or 5 is related to the presence of trend in the error correction term form (level equation) of the CEC model. This means that the CAB can display a trend in the long-run. Also in case 5, the null hypothesis of the bounds test does not restrict the intercept term of the CEC equation to be zero. This signifies that the CAB mostly exhibits more surpluses or deficits than an equilibrated CAB.

Before running the bounds cointegration test, it is important to know that the dependent variable is $\mathrm{I}(1)$ to proceed with ARDL in the CEC model. Also, it is required that the independent variables are not $\mathrm{I}(2)$; this means that the series should not contain two unit-roots i.e. requiring differencing twice to induce stationarity.[17] In our dataset, all unit root test results confirmed that none of the variables are stationary at their second differences (Tables C1 and Table C2). Therefore, the ARDL bounds test approach is used to investigate a cointegrating relationship between CA-to-GDP, ADR variables and economic growth. Also, as our sample is small, the asymptotic critical values of PSS (2001) are not appropriate, but we can use the small-sample critical values of Narayan (2005) to correctly evaluate the bounds statistics in cases 2, 4 and 5. The results of the bounds cointegration test are detailed in Tables D of Appendix 1.

Before deciding whether the null hypothesis of no levels relationship is rejected or not, we need to run various statistical diagnostics to validate the outputs of the model specification. The key assumption of ARDL approach is the absence of serial correlation. For cases 2-4-5 (see Table D.3, Appendix 1), it appears that the residuals are not serially correlated because the statistic LM leads to accept the null hypothesis of no serial correlation. Also, the heteroskedasticity test of Breusch-Pagan-Godfrey, under the null hypothesis of no heteroskedasticity, shows that we accept the null hypothesis, and then the residuals are homoskedastic and do not display ARCH effects. In addition, the Ramsey Reset test, with the null hypothesis of no misspecification, indicates that the model is well-specified. Furthermore, the test for variance inflation factor (VIF) reveals that there is no evidence of multicollinearity, but for case 4, it

[16] In the case 2 where the ECT includes the intercept, the bounds cointegration test assumes the null hypothesis that $b_0 = b_i = a_0 = 0, \forall\, i$. In the cases 4 and 5 where the ECT contains the trend, we test the null hypothesis that $b_0 = b_i = a_1 = 0, \forall\, i$ and that $b_0 = b_i = 0, \forall\, i$, respectively.

[17] For more details on the ARDL strategy in testing and diagnosing the bounds cointegration, see the article of Philips (2018).

displays a very slight multicollinearity due to the deterministic trend component. The Cumulative Sum of recursive residuals and of squares recursive residuals indicate the stability for the CA-to-GDP equation in all the cases 2 and 4 or 5.[18]

For all the cases at the significance 1%, there is no levels relationship between CA-to-GDP, ADRs variables and GRP growth (see Tables D1 et D2, Appendix 1). As well, for cases 4 and 5 at the significance 5%, we accept the null hypothesis of no cointegration as the F-statistics are less than the lower stationary bound. However, case 2 leads to an inconclusive inference for the test of no cointegration because the F-statistic lies between I(0) and I(1) values. This means that there is no evidence of cointegrating relationship as all the variables in the error correction equation are I(1) (see Appendix 1 Tables C: tests of unit root).

4. Modeling

4.1 Model specification and covariances tests

Using the stylized facts of Saudi Arabia economy, that includes its international openness by hosting a large proportion of immigrants and its international liquidity outflows (Bracke and Fidora 2008) due to the surpluses in CAB, also based on literature review and the explorative analysis of correlations between demographic structure and macroeconomic series (Tables A), we can highlight that the behavioral bi-life cycle holds for natives and immigrants but in different ways.

Our study makes a usual LCH for native ADR supposing that its increase leads to the CAB's worsening by splitting the ADR into two ADRs. The LCH means that the working-age group (between 25 and 65 years) tends to save relatively more than other age-groups, while the young (less than 25) and old-aged (more than 65) groups tend to dissave. Then, at a given level of the working-age group, any increase in ADR will lead to more dissaving of working-age people to support the needs of younger and older people. It means that the overall economy or community will face a greater burden in supporting the young and old-age population. Therefore, as the saving rate decreases, the CAB worsens.

For the immigrant ADR, the conventional LCH does not work as it is defined because most immigrants live alone in Saudi Arabia and keep their family members in their native countries. Then, they remit a considerable share of their labor income to their offspring and communities. First, this behavior seems to contribute marginally to reducing the CAB. However, such remittance outflows are only. on average, approximately 5.8% of GDP, and the economic contribution of immigrants generates more revenues and earnings for Saudi's economy. Similarly, at a given level of the immigrant working-age

[18] To save space, we have not displayed all ARDL outputs in Appendix, but all output are available upon request.

population, any increase in immigrant ADR will incite them to more working time to financially support the increasing needs of their young and old age relatives. The immigrant tends to find any opportunity in seeking additional revenues. Consequently, with such aggregated behavior, we consider that the immigrant ADR contributes to improve the CAB.

In the long-run, due to the immigrants' rationale, we postulate that a bi-life-cycle hypothesis (bi-LCH) holds in Saudi's economy but opposite directions. Therefore, there is a need to treat the dynamic effects of dual-age structure on CABs, and the interactions between native and immigrant ADR lead to some net effects. Depending on the effect that prevails on the other, the resulting two effects are an empirical issue related to the dataset that reflects the main features of the economy under study. According to previous explanations, we can postulate these working hypotheses that

(i) an increase in native age-dependency rate negatively affects the CAB: $\frac{\partial cay}{\partial s\_adr} < 0$;

(ii) an increase in immigrant age-dependency rate has a positive effect on the CAB: $\frac{\partial cay}{\partial ns\_adr} > 0$;

(iii) an increase in economic growth positively affects the CAB: $\frac{\partial cay}{\partial g\_gdp} > 0$.

On the third hypothesis, it is known that the CAB results from the international trade balance, income balance, and transfer balance. In the case of Saudi economy, there is a large linkage between exports and GDP as the exportation of oil has an eminent effect on the GDP through the investments. Furthermore, as indicated by Sachs et al. (1981), the correlation between output and CA critically depends on the underlying shocks that move these variables. According to Sachs et al. (1981, page 226), the effects of variations in consumption demands and government expenditures can be largely compensated by variations in export demands and technology, both can lead to a positive correlation between CA and GDP. According to Das (2016), theoretically even though there is a negative effect of GDP growth on CA-to-GDP, it is not always verified in the empirical works because it depends on the features and stylized facts of the economy. Das (2016) and Altayligil and Cetrez (2020) find that, in the emerging countries panel, the real GDP growth is positively related to the CAB, whereas it is negatively linked to the CAB in industrialized countries.

Furthermore, according to Altayligil and Cetrez (2020), there are two groups of studies analyzing the CAB, the first one has worked on the responses of CAB to shocks using few specific determinants. The second one using alternative framework to identify the effects of institutional, financial, demographic as well as macroeconomic determinants. Altayligil and Cetrez (2020, page 7:23) assert that for countries exporting high technological goods, it is expected that their GDP growth will have a positive effect on

CAB. Similarly, in emerging countries as Saudi Arabia, the high exportation of oil and petrochemical products generate more economic growth, which would lead to a net positive effect on CAB. Accordingly, we believe there are some room for monitoring positive relationship between GDP and CA balances, and this is valid for Saudi Arabia. Nevertheless, as mentioned by Narayan et al. (2020), to be on a sustainable path of the CAB the nation need to increase growth of exports and/or reduce growth of imports.

The first relationship (i) is theoretically and empirically supported in most papers cited such as Gudmundsson and Zoega (2014). The third relation (iii) states the positive effect of economic growth on the CAB. Using this assumption and since the main immigrant population is at working-age i.e. eligible for jobs, and in accordance with Li et al. (2007) and Ortega and Peri (2009), we assume that the immigrant age-dependency ratio is a contributing factor to economic growth. Consequently, since the ratio $\left(\frac{\partial cay}{\partial g\_gdp}\right)/\left(\frac{\partial ns\_adr}{\partial g\_gdp}\right)$ is expected to be positive, because the immigrant ADR is governed by the demand labor from private and public enterprises of the host country implying that $\frac{\partial ns\_adr}{\partial g\_gdp} > 0$, the relationship (ii) holds. According to Boubtane et al. (2016) the empirical results confirm the theoretical model stating the prevalence of a positive effect of immigration on GDP per worker even in countries with non-selective migration policies. They outline a theoretical model using a conditional Cobb-Douglas function and assume as Solow model that the labor factor increases at a constant rate. From their theoretical model and at the steady-state, they assert that the net effect of immigrant is ambiguous and depends on the relative human capital contribution of native and immigrant, immigration rate and parameters of the production function. The sign of the effect is mostly an empirical issue because econometric investigation can lead to assess the overall effect of immigration on economic growth. As well, by using the canonical augmented version of Solow model, Borjas (2019) asserts that there is a consensus on a central point: immigration positively contributes to the GDP growth when the immigrant flow is composed of high-skill workers.

The theoretical framework of this study seems different, but as in a general equilibrium over-lapping generations (OLG) modeling, it works with plausible hypotheses from general economic theory. Based on the study of Cerrato et al. (2015), Ghassan et al. (2019) explored the long-run CA-to-GDP ratio in the present value model framework (PVM) using overlapping generations model. By considering the entire population without distinguishing natives and immigrants, Ghassan et al. (2019) suggest a theoretical model that can derive the effects of GDP growth and population growth on current account. Under some stability conditions, they deduce in the steady-state balanced growth path that the long-run effects on CA-to-GDP ratio could have any sign as there is no sign presumption. Such indefiniteness is due to the complexity and interdependence of the long-run factors related mainly to consumption and investment processes (Blanchard et al. 2002). The empirical exploration can help to identify some effects and implications on the CA dynamics of that factors.[19]

The empirical modeling focuses on explaining the impact of the hybrid demographic changes and economic growth variability on Saudi CAB. In addition to the main dependent variable CA-to-GDP, we consider that GDP growth and immigrant ADR are determined endogenously. Also, as the young and old age population depend on economic growth (Hondroyiannis et al. 2005, Hondroyiannis et al. 2004, Hondroyiannis et al. 2002, Prskawetz et al. 2004), it is plausible to assume that Saudi ADR is determined endogenously.[20]

As Sims (1980) asserted, the pioneer of Vectorial Auto-Regressive (VAR) processes, VARs are a meaningful tool in organizing data, building and comparing alternative models. Sims (1980) suggested a dynamic multivariate model that requires selection underlying variables and optimal lag lengths using statistical criteria. Kilian (2013) indicated that Sims' VAR approach provides a suitable framework for testing alternative theories, economic reasoning and analyzing economic policies. Nevertheless, he indicated that it is particularly difficult to interpret and examine the coefficients themselves in regression equations. However, the VAR-based impulse response functions provide valuable information leading to understand how shocks propagate through the economy. Furthermore, Sims (1980 or 1977 page 32) modified the conventional statistical test of likelihood ratio and showed that this modification favors the null hypothesis.

The dynamic interactions between economic and demographic variables are explored through VAR modeling because such a statistical approach does not require a theoretical economic framework in its reduced form. Nevertheless, when we address unobserved structural shocks through the reduced VAR, we need the economic theory, a-priori economic reasoning, a-priori restrictions and identification

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[19] As indicated by Sachs (1982), it is important to develop a small theoretical model that focuses on few fundamental stochastic variables in analyzing the CAB. We have in progress a theoretical research project that distinguish native and immigrant population in the framework of present value modeling using overlapping generations.

[20] As suggested by anonymous referee, we assess that we can employ other explanatory factors that could influence the nexus CA-population age structure such as the real exchange rate as raised by Aloy and Gente (2009), the world oil prices (Cooper 2008), and international liquidity. These factors are interrelated, and we hope to investigate the relationship of these variables in future studies. Nevertheless, it appears that the SAMA adopts a quasi-fixed nominal exchange rate to the US dollar. But it remains that the USD volatility directly impacts the price level in Saudi economy, and indirectly its CAB. Also, in the long-run, it is expected that the changes in the real oil price would influence the real exchange rate (Habib and Kalamova 2007). However, within the VAR approach, it is already enough to work with four variables in managing the economic and financial meaning of the impulse response functions.

assumptions to have credible structural shocks by giving economic or financial meanings to the interactions between the shocks of underlying variables.

In our empirical work, in addition to the EG and Hansen tests of cointegration, we have used the canonical cointegrating regression (CCR, Park 1992) and the bounds cointegration test (PSS 2001) to check the robustness of our results.[21] Using the fully modified ordinary least square (FMOLS) method, the Park cointegration test employs stationary transformations on data in detecting long-run relationship between CA-to-GDP, Saudi age-dependency rate, immigrant age-dependency rate and economic growth. The null hypothesis H_0 of Park's cointegration test is that there is a cointegration, as we have $\chi_2^2 = 8.04$ corresponding to a P-value 0.017, we reject H_0. In addition, the ARDL cointegration framework can be suitable for small samples as the EG cointegration approach. The null hypothesis is that there no cointegration between the underlying variables of the regression explaining the real CA-to-GDP by economic growth and age-dependency rates. We find that, at 1% of the significance level, all the relevant bounds statistics are less than the lower critical values. Using ARDL cointegration test, we conclude that there is no level relationship in the regression between the underlying variables. The absence of cointegration can be explained by the differences in the intrinsic logical growth of each series. The non-evidence of cointegration makes it suitable to estimate a VAR model since there is no loss of information in the long-run.

Assuming that the conditional expectations obey a linear projection and based on lags of the underlying stationary variables of the VAR model, we can write this model as follows:

$$Y_t = cst + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t \iff C(L)Y_t = \varepsilon_t \tag{1}$$

where $Y_t' = (dcay_t, ds\_adr_t, dns\_adr_t, dg\_gdp_t)$, $C(L)$ is the polynomial matrix of lag length, and ε_t represents the reduced error term with $E(\varepsilon_t \varepsilon_t') = \Omega_\varepsilon$ and $E(\varepsilon_t \varepsilon_{t-i}') = 0$. The VAR model can be arranged as a SVAR model by imposing parameter-restrictions on A and B matrices. We obtain the following AB-model (Amisano and Giannini 1997, Breitung et al. 2004):[22]

$$AY_t = cst_0 + \sum_{i=1}^{p} \boldsymbol{A}_i^* Y_{t-i} + Bu_t \tag{2}$$

where $\boldsymbol{A}_i^*$ is the matrix of structural coefficients and u_t is the structural error or shock. This error is assumed to be a white noise process with zero mean and time-invariant variance-covariance matrix Σ_u.

[21] According to Ogaki (1993), the null of cointegration is harder to construct than the null of no cointegration. Additionally, he indicates that the empirical estimation of long-run covariances parameters, by using VAR pre-whitening method, can substantially improve the properties of CCR estimators in small samples.

[22] The matrices A and B are both unknown constraints and parameters based on economic analysis and economic hypotheses. They serve to shift from reduced errors to structural errors that have economic meaning.

When the matrix A is invertible, it allows to modeling contemporaneous relations among the variables of Y_t. By pre-multiplying with A^{-1}, $\boldsymbol{A}_i = A^{-1}\boldsymbol{A}_i^*$ for $i = 1,2, \dots, p$, we obtain the VAR equations and the relation between reduced and structural errors is $\varepsilon_t = A^{-1}Bu_t$ and its variance-covariance matrix is $\Omega_\varepsilon = A^{-1}BB'A^{-1'}$ by supposing that the shocks u_t are orthogonal (instantaneously uncorrelated) i.e. $\Sigma_\mathrm{u} = \mathrm{I}$.

Before the estimation, we can reduce the effects of outliers in the underlying series by adopting the Time Series Regression with ARIMA Noise, Missing Observations and Outliers (TRAMO) program using the linearized series in the VAR estimation. Next, many statistical steps are implemented before selecting the VAR equation, leading to reduced residuals. First, by specifying a VAR model as in the equation (1), we determine its lag length. Before this, the underlying variables have to be stationary, and the residuals of each equation should not be correlated to another equation. Following the nonstationary series through KPSS stationary tests and Zivot-Andrews unit root tests, we accept that the demographic and economic variables are $I(1)$. Therefore, we use the variables in first difference. Also, we find that the optimal lag order using all selection criteria is 1 (see Table 1, Appendix 1). This leads to select VAR(1) model, which reduces at its lowest likelihood level of serial correlation between VAR residuals. Effectively, Table 2 (Appendix 1) shows that the null hypothesis of no serial correlation between the reduced residuals is accepted. Also, the stability condition holds for $VAR(1)$ because all autoregressive characteristic polynomial roots lie within the unit circle.

Furthermore, it is of interest to test the heteroskedasticity between variances of VAR residuals. This test is decisive because if the nullity of residual covariances is true, we cannot justify the SVAR modeling. We have to test whether the calculated variance-covariance matrix Ω_ε is a diagonal matrix i.e. there is no cross-correlation across VAR equations. The matrix Ω_ε is shown in Table 3.1 (Appendix 1), which serves to run such a test. The log-likelihood ratio (LR) test, as suggested by Sims (1980), or the Lagrange multiplier (LM), is run for testing the joint significance of the off-diagonal of residual covariances matrix (Enders 2004, Greene 2012 page 604).[23]

The null hypothesis is that the off-diagonal residual covariance elements are equal to zero, which corresponds to $\mathrm{diag}(\widehat{\Omega}_\varepsilon)$. Empirically, we compute this covariance matrix with $(1/T)\hat{\varepsilon}'\hat{\varepsilon}$ from the ordinary least squares (OLS) residuals of each individual VAR equations. These OLS estimates are

[23] The Lagrange multiplier statistic of Breusch-Pagan (1980) can be determined by $LM = T\sum_{k=2}^{K}\sum_{l=1}^{k-1} r_{kl}^2$ where r_{kl} is the residual correlation coefficient between equations k and l defined by $\hat{\sigma}_{kl}/(\hat{\sigma}_{kk}\hat{\sigma}_{ll})^{1/2}$. The limiting distribution of this statistic is χ_q^2 as for the LR statistic. The LM statistic is easier to calculate because it does not require the maximum likelihood estimates of Ω_ε. From Table 3.2 (Appendix 1), we obtain that $LM = 20.33$ which is greater than the critical value of 12.59, leading also to reject the null hypothesis of diagonal covariance matrix.

equivalent to the maximum likelihood (ML) when we suppose that the residual covariance is diagonal, and the errors are normally distributed. Additionally, the VAR residuals normality tests display that the residuals are multivariate normal (To save space, we have not presented the corresponding Tables). The alternative hypothesis is defined by the unrestricted $\widetilde{\Omega}_\varepsilon$ estimated by ML method.

The null hypothesis $H_0: \sigma_{12} = \sigma_{13} = \sigma_{14} = \sigma_{23} = \sigma_{24} = \sigma_{34} = 0$ is tested against the alternative hypothesis $H_1: \sigma_{12} \neq \sigma_{13} \neq \sigma_{14} \neq \sigma_{23} \neq \sigma_{24} \neq \sigma_{34} \neq 0$ using $LR = 2(LL_U - LL_R) = -2(LL_R - LL_U)$ where LL_U and LL_R are the maximum values of the log-likelihood function with unrestricted and restricted models, respectively. We can obtain the exactly equivalent value by basing the statistic of LR on the difference between the restricted covariances matrix and unrestricted covariances matrix as follows

$$LR = T\left(\ln\left|\widehat{D}_R\right| - \ln\left|\widetilde{D}_U\right|\right) = T\left(\ln\left|\text{diag}\left(\widehat{\Omega}_\varepsilon\right)\right| - \ln\left|\widetilde{\Omega}_\varepsilon\right|\right) = T\left(\sum_{k=1}^{K} \ln \hat{\sigma}_k^2 - \ln\left|\widetilde{\Omega}_\varepsilon\right|\right)$$

where $\widehat{D}_R$ is the matrix of cross products of residuals for the restricted model, $\widetilde{D}_U$ is the same matrix for the unrestricted model. Sims (1980) modifies the LR-statistic by using the coefficient $(T - m)$ instead of T where m is the total number of regressions coefficients estimated, divided by the number of equations. But he indicated that this modification favors the null hypothesis. The statistic LR is distributed following χ_q^2 where the degree of freedom q is equal to $K(K-1)/2$ restrictions on the covariance matrix, K is the number of variables in the VAR model.

The log-likelihood value of the restricted model under the null hypothesis comes from the single estimate of the equations in the VAR model and is defined by:

$$LL_R = LL_{dcay} + LL_{ds\_adr} + LL_{dns\_adr} + LL_{dg\_gdp}$$

It comes from the output of VAR estimates that $LL_R \simeq 379.0805$. Also, we get the log-likelihood value of the unrestricted model, i.e., under H_1 from VAR estimates as $LL_U \simeq 389.5954$.

From the log-likelihood values that $LR = 2(389.5954 - 379.0804) \simeq 21.03$ and from covariance matrices, we obtain the same result, $LR = 42(29.9036 - 29.4029) \simeq 21.03$; the statistic $LR_{Sims} = (42 - 5)(29.9036 - 29.4029) \simeq 18.53$. The critical value at 95% level of confidence and with a degree of freedom $q = 6$ is 12.59. The calculated values are greater than the critical value, so we reject the null hypothesis and then the covariance are not jointly zero, i.e., the reduced errors in different equations are jointly and contemporaneously correlated.[24] This statistical feature justifies implementing the SVAR model which indirectly considers the contemporaneous effects between underlying variables.

4.2 Restrictions and identification of SVAR model

The AB-Model cannot be estimated without combining the restrictions on A and B consistent with a-priori theoretical economic expectations (Amisano and Giannini 1997).[25] This approach allows identifying economic and population shocks by relating reduced innovations to structural shocks. Regarding the underlying variables of the basic VAR model with $K = 4$, twenty-two restrictions should be imposed on the matrices A and B, which are nine zeroes in each matrix A and B and four unit-elements in the diagonal of A.

As there is a relationship between the reduced innovations and the structural shocks from the AB-model, we match the original VAR variables to the corresponding economic shocks, i.e., as a new set of variables. We assume that the reduced innovations associated with the current account originate from international trade, income, and transfers shocks, TIT. The reduced innovations of Saudi ADR emanate from domestic working-age population shocks, SWP, whereas the immigrant ADR is derived from demand labor dynamics for immigrant workers, DEL. The reduced residuals of GDP growth arise from the real domestic supply, DOS.

We consider that the Saudi ADR is governed by the social and economic policies leading to a growing population size and a smooth demographic shift in the age structure. As the Saudi working-age population is increasing faster than the elderly population (Asharaf and Mouselhy 2013), and considering the immigrant contribution to the total working age, we expect that the ADR decrease is accompanied by more economic growth that would improve the CAB. This result is confirmed by the negative correlation between the CA-to-GDP and Saudi- or total ADR (Table 1). Consequently, a positive structural shock in native working-age, i.e., active-age population, positively impacts the innovations of the CA-to-GDP process through consumption and investment behaviors.[26] Bonham and Wiemer (2013) observed that the

[24] The test of Brown and Forsythe (1974) provides that BF-statistic is about 33.42 with a p-value of $6.54E - 17$, meaning a strong evidence of heteroskedasticity between residuals-VAR variances.
[25] The number of non-redundant elements of variance-covariance matrix Ω_ε is $K(K+1)/2$, where K is the number of variables in the VAR. Accordingly, we can identify just $K(K+1)/2$ parameters of the structural VAR. Since there is $2K^2$ elements in the matrices A and B, the number of required restrictions to identify the full *AB*-model is $2K^2 - K(K+1)/2$ which is equal to $\mathrm{K}^2 + \mathrm{K}(\mathrm{K}-1)/2$. If the matrix A or B is set to be the identity matrix, then $K(K-1)/2$ restrictions remain to be imposed.
[26] By definition, an increase in active age population corresponds to a decrease in age-dependency rate (ADR), and vise-versa.

falling in age-dependency rate facilitated a high saving rate which depends on economic growth and would positively impact the CAB in China and other Asian economies.

Also, due to the bi-population system leading to a dual labor market, another stimulus from the increased immigrant ADR will positively affect the CA-to-GDP dynamic (Table 1). The immigrant ADR is governed by the demand for labor from the private and public enterprises of the host country. Any shocks in such demand labor, depending on the GDP growth process, would affect the immigrant ADR.

Based on the literature review and the previous economic analysis of the interactions between bi-ADR, GDP growth and CA-to-GDP, we define the following system (3) by considering that the first equation supposes that CA-to-GDP innovation ε_t^{CAY} is determined by the structural shocks of international trade, income, and transfers growth through the parameter b_{11}. The second equation is constructed from the bi-LCH, assuming that Saudi ADR innovation $\varepsilon_t^{s\_ADR}$ is driven by both shocks in Saudi working-age population growth and demand labor for immigrants through the structural parameters b_{22} and b_{23}. The third equation exhibits that the immigrant ADR innovation is determined jointly by the innovation in CA-to-GDP ratio innovation and by the structural shocks occurring in demand labor for immigrant and the real domestic supply. The fourth equation shows that the innovation in real GDP growth is driven jointly by the innovations in CA-to-GDP growth and structural shocks in domestic supply growth. Hence, we can suggest the following relationship between the reduced innovations and structural shocks in the system (3).

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ -a_{31} & 0 & 1 & 0 \\ -a_{41} & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{CAY} \\ \varepsilon_t^{s\_ADR} \\ \varepsilon_t^{ns\_ADR} \\ \varepsilon_t^{g\_GDP} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & b_{23} & 0 \\ 0 & 0 & b_{33} & b_{34} \\ 0 & 0 & 0 & b_{44} \end{bmatrix} \begin{bmatrix} u_t^{TIT} \\ u_t^{SWP} \\ u_t^{DEL} \\ u_t^{DOS} \end{bmatrix} \tag{3}$$

where the coefficients a_{ij} stand for the response of variable i to an unexpected shock in variable j; the coefficients b_{ij} are the response of variable i to a structural shock in variable j. The estimation of this system depends on the parsimony of the parameters number and their statistical significance using bootstrapping to get the reliable standard deviation of the AB-model parameters.[27] The AB-system, with fourth equations, shows that the identification of SVAR is achieved in the light of the plausible economic

[27] The trade-off between the just-identification and the statistical significance of the parameters in AB-model leads to prefer an over-identification, requires to test the null hypothesis of the restrictions validity using likelihood ratio (LR) statistic. This is asymptotically distributed as $\chi^2_{(q_u-q_r)}$ where q_u and q_r are the number of restrictions under just-identification and over-identification, respectively. In our case, we find that $\chi^2_{(10-8)} = 0.0425$ with a p-value 0.979, meaning that there is no statistical significance between outcomes of restricted and unrestricted identification.

analysis, and by imposing a specific set of identifying restrictions a_A and b_B on A and B. These restrictions appear after defining the economic parameters as unknown constraints on both A and B. The natural set of restrictions are only contemporaneous because, in the SVAR modeling, the lagged dynamics are unrestricted. The necessary condition requires that the number of identifying-restrictions on A and B has to be superior (overidentification) or equal (just-identification) to the number of required restrictions of the full AB-model, i.e., $a_A + b_B \geq 2K^2 - K(K+1)/2$ (in our case, $13 + 9 \geq 32 - 10$). The sufficient condition is to check the non-singularity of the related information matrix, a function of the parameters to be estimated (Amisano and Giannini 1997).[28]

When the identification and resolution of the system (3) are made, the parameters of AB-model could be estimated by minimizing the negative of the concentrated log-likelihood:

$$\ln L_c(A,B) = -\frac{KT}{2}\ln(2\pi) + \frac{T}{2}\ln|A|^2 - \frac{T}{2}\ln|B|^2 - \frac{T}{2}\mathrm{tr}\left(A'B'^{-1}B^{-1}A\widehat{\Omega}_\varepsilon\right)$$

where $\widehat{\Omega}_\varepsilon = T^{-1}\sum_{t=1}^{T}\hat{\varepsilon}_t\hat{\varepsilon}_t'$ is the estimated variance-covariance matrix of the VAR residuals with $\hat{\varepsilon}_t = Y_t - \widehat{cst} - \widehat{\boldsymbol{A}}\boldsymbol{Z}_{t-1}$ where $\boldsymbol{A} = \left(\boldsymbol{A_1}, \boldsymbol{A_2}, \dots, \boldsymbol{A_i}, \dots, \boldsymbol{A_p}\right)$ is the parameters matrix with an order $K \times Kp$ and $\boldsymbol{Z}_{t-1}' = \left(Y_{t-1}', Y_{t-2}', \dots, Y_{t-p}'\right)$.

4.3 SVAR estimation

Using the structural factorization, we derive the estimated shocks by the maximum likelihood for the SVAR model from the estimated VAR residuals. The estimated structure of shocks is shown in the system (4), where the values between parentheses correspond to the p-values indicating the statistical significance of the estimates.

$$\begin{cases} \varepsilon_t^{CAY} = \underset{(4.947E-20)}{0.0959}\, u_t^{TIT} \\ \varepsilon_t^{s\_ADR} = \underset{(4.993E-20)}{0.0143}\, u_t^{SWP} - \underset{(0.0210)}{0.0053}\, u_t^{DEL} \\ \varepsilon_t^{ns\_ADR} = \underset{(0.0033)}{-0.0365}\, \varepsilon_t^{CAY} + \underset{(4.992E-20)}{0.0079}\, u_t^{DEL} + \underset{(0.0485)}{0.0023}\, u_t^{DOS} \\ \varepsilon_t^{g\_GDP} = \underset{(0.0214)}{-0.1424}\varepsilon_t^{CAY} + \underset{(4.948E-20)}{0.0385}\, u_t^{DOS} \end{cases} \quad (4)$$

The effects of structural shocks on the variables of interests are dynamics, and can be explored using the impulse response functions (IRF). As the process of Y_t is stationary, we can write its Wold moving average representation, used to investigate the dynamic interactions between the endogenous

[28] For more details on SVAR identification and related algebra see Lucchetti (2006).

variables of the VAR model using the IRF: $Y_t = \Psi_0 u_t + \Psi_1 u_{t-1} + \Psi_2 u_{t-2} + \cdots + \Psi_s u_{t-s} + \cdots$ where $\Psi_s = \Phi_s \widetilde{\mathrm{A}}^{-1}\widetilde{\mathrm{B}}$ for $s = 0,1,2, ...$, and $\Phi_s = \widehat{\boldsymbol{A}}_1^s$ with $\Phi_0 = I$. The $(i,j)^{th}$ coefficients of the matrices Ψ_s are thereby interpreted as the expected response of variable $Y_{i,t+s}$ to a unit change in the structural shock $u_{j,t}$. For this purpose, we determine the partial multipliers as follows $\Psi_0 = \tilde{A}^{-1}\tilde{B}, \Psi_1 = \widehat{\boldsymbol{A}}_1\Psi_0, \Psi_2 = \widehat{\boldsymbol{A}}_1^2\Psi_0, ...$ where A, B are the estimates of the AB-model, and $\widehat{\boldsymbol{A}}_1$ is the estimated matrix of parameters from $VAR(1)$. Also, the total impact matrix, i.e., the matrix of long-run effects can be calculated from $\Psi_\infty = \left(I - \widehat{\boldsymbol{A}}_1\right)^{-1}\Psi_0$ (Breitung et al. 2004 and Lütkepohl 2007). The results are as follows

$$\Psi_0 = \begin{bmatrix} 0.0959 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0143 & -0.0053 & 0.0000 \\ 0.0035 & 0.0000 & 0.0079 & 0.0023 \\ 0.0137 & 0.0000 & 0.0000 & 0.0385 \end{bmatrix}, \quad \Psi_1 = \begin{bmatrix} 0.0130 & -0.0102 & 0.0132 & 0.0112 \\ 0.0007 & 0.0140 & -0.0096 & -0.0030 \\ 0.0027 & 0.0004 & 0.0074 & 0.0026 \\ -0.0160 & -0.0025 & 0.0002 & -0.0164 \end{bmatrix}$$

$$\Psi_2 = \begin{bmatrix} 0.0000 & -0.0106 & 0.0167 & 0.0024 \\ 0.0003 & 0.0132 & -0.0132 & -0.0033 \\ 0.0024 & 0.0009 & 0.0068 & 0.0022 \\ 0.0050 & -0.0004 & -0.0005 & 0.0061 \end{bmatrix}, \ldots, \Psi_\infty = \begin{bmatrix} 0.1614 & 0.0069 & 0.1662 & 0.0595 \\ -0.0573 & 0.0308 & -0.2025 & -0.0630 \\ 0.0117 & 0.0246 & 0.0077 & 0.0037 \\ 0.0041 & -0.0059 & 0.0122 & 0.0302 \end{bmatrix}$$

The simultaneous and contemporaneous relationship between VAR variables and the economic and demographic shocks indicates that a DEL shock decreases the Saudi ADR through the matrix Ψ_0. This negative structural slope, about -0.0053, explains that the immigrant and native workers are more complements than substitutes in terms of shock-response.[29] The instantaneous impact of real domestic supply on the immigrant ADR is positive, about 0.0023. Also, the immediate impact of a positive shock in international trade, income and transfer increases the immigrant ADR by approximately $+0.0035$. This means that an improvement in international markets encourage the economy to hire more immigrant workers.

The dynamic long-run relationships between the underlying variables, through the total impact matrix of the shocks i.e., Ψ_∞, show the extent of the cumulative negative effect with -0.2025 between structural shocks in the growth of DEL and the responses of native ADR growth. This negative structural relation explains that the immigrant and native workers are more complements than substitutes in the long-run.[30] As well, even in the long-run, the cumulative impact of the growth in DEL on the GDP growth is

[29] Because, as the young and elderly population do not regress, a decrease in the Saudi ADR means more Saudi working-age population that occupy jobs in the labor market.

[30] According to McKinsey Global Institute Report (2015), the complementarity holds mostly in the private sector where the immigrants are predominantly employed, but they appear more substitutes than complements in the public sector dominated by Saudi nationals.

positive, approximately $+0.0122$; the SWP shock is associated with a negative GDP growth of about -0.0059. In the long-run, the net impact of the two sources of working-age population shocks on GDP growth is positive, approximately $+0.063$, due to the predominant contribution of skilled immigrant workers over the native workers. These findings provide new insights in studying the relationship between bi-population growth and economic growth within the population's neoclassical theory. However, the cumulative long-run impact of a positive shock in international trade, income, and transfer growth could increase the immigrant ADR by approximately $+0.0117$. This means that a long-run improvement in international markets motivates the Saudi economy to employ fewer immigrant workers. In the next section, we will discuss the processes of the responses of the underlying variables to diverse structural shocks.

As indicated in Stock and Watson (1996, 2001), the structural impulse responses functions from SVAR modeling could be sensitive to changes in the lag length, sample period and identification restrictions. Therefore, we check for the robustness of the impulse-response function (IRF) results by modifying the lag length of the reduced VAR, this checking shows that the shapes, signs, and magnitudes overall remain robust to the changes from 1 lag to 2 lags.

The confidence intervals of the structural IRF are computed using Monte-Carlo simulations with 5000 replications. As we estimate a stationary VAR model in first differences, the IRF are consistent at long horizons. Consequently, stationarity means that the impulse responses should tend toward zero as the horizon increases. All lines indicate the impulse responses; their confidence bands are calculated, but not displayed in Figures for the congestion purpose. The standard errors of the responses are generated by an asymptotic analytic method. The standard error confidence intervals are not divergent, and the results indicate appropriate bands that the reactions are significant globally.[31]

5. Results and Discussion

The Saudi working-age population is considered as the labor supply of the economy, while the immigrant working-age population depends on the DEL by the host economy. The native and immigrant workforce are two labor sources: complements or substitutes (Grossman 1982, Ortega-Peri 2009). The resulting outcome between these two effects is more an empirical issue. It depends on the macro-dynamic of the labor market, relying on the intensity of the economic activities and the management and technological skills into the productive sectors of the economy (Peterson 2017). The relationship between the bi-

[31] All data and empirical outputs are available upon request.

population growth, the current account, and economic growth depends on specific conditions prevailing in the countries and their economic areas and financial connection.

Figures B.1 (Appendix 2) show that in the short-run, a positive shock of international trade-income-transfers (TIT) leads to a decrease the CA-to-GDP, but this impact changes throughout the temporal horizon. In contrast, any negative shock will lead to speedy correction of the CA-to-GDP process. The dynamic mechanism behind this correction could be due to further exports, mostly when the negative shock comes from incomes and transfers. The agents of the economy would respond by smoothing their consumption in response to shocks, supporting such correction. Moreover, there is a no sufficiently hump-shaped function as the quick decreasing reactions of CA-to-GDP turn back, after three years, quickly enough to have an increasing path for only two years ahead and become stable for a long term. Such outcome can be due to the sticky behavior of the CAB to exogeneous shocks.

A positive shock in the domestic working-age population (SWP) shows interesting dynamics on the CA-to-GDP path. It leads to a decrease in this path during 3^{rd}-to-8^{th} horizon periods. But this shock increases the CA-to-GDP in the 2^{d} period and gradually for long periods from the 9^{th} year with a hump-shaped positive reaction. In other words, a positive shock in SWP, increasing the Saudi active-age, would improve the CAB in the long-term. During the first seventeen years, the effects of Saudi working-age population shocks and demand labor for immigrant shocks on the CA-to-GDP moved in opposite directions. But the combination of the two effects leads to improve the CA-to-GDP (Figures B.1) as the positive effects of DEL shocks dominate and cancel out the negative effects of SWP in the medium term. As predicted theoretically in sub-section 4.1, there is a cumulative positive contribution of the immigrant working-age population on the CA-to-GDP ratio. Also, as predicted, the positive real domestic supply shocks largely and positively impact the CA-to-GDP, generating a hump-shaped reaction. This indicates that any positive shock in macro-supply would positively affect the current account growth in the short to medium term up to 25 years ahead. However, in the long-run, these effects decay very slowly (Figures B.1).

By considering the IRF of Saudi ADR, we find a negative hump-shaped reaction to immigration policy shocks during a generation, i.e., positive shocks in the DEL (Figures B.2). When the shocks emanate from immigrants' working-age, there is a complex mechanism from complementarity process (part of the decreasing response curve) to the substitutability process (part of the increasing response curve) between the immigrant and Saudi workforce.[32] This means that, in short and medium terms, an increase in the immigrant working-age population drives a decrease in Saudi ADR (i.e. increase of Saudi working-age population); and in the long-term to its increases even though it remains negative for up to 25 years. The first complementarity process can be because the flow of immigrant workers can enlarge the labor market prospects of Saudi working-ages for some specific specialties and skills (Dustmann et al. 2005). Moreover, the rationale behind the second process of substitutability for a long period is that native employment has progressive adverse effects on the immigrant workforce in the Saudi labor market for a long period ahead. The cumulative negative effects dominate, meaning that the Saudi ADR reactions lead to its decrease; therefore, more Saudi workers will be in the labor market.

However, the immigrant inflows do not strongly affect the established native workers, but could affect potential native workers mainly during bad economic cycles. Nevertheless, the substitution mechanism between immigrants and Saudi workers would not be problematic as several immigrants have low skills in the long-run. According to our empirical results and as the immigration level is highly regulated by the Saudi government, the immigrants appear to be more complements than substitutes to Saudi workers. This finding is supported in the empirical work of Boubtane et al. (2013).

Furthermore, and from Figures B.3, during a generation, i.e., a horizon of the first twenty-five years, the positive shocks in SWP growth generate a positive hump-shaped reaction of the immigrant ADR growth. This means that when the shocks emanate from Saudi working-age population, there is a complex mechanism from the substitutability process to the complementarity process between Saudi and immigrant working-age population. Regarding shocks, this outcome indicates that the cumulative positive effects dominate, meaning that the immigrant ADR reactions lead to its increase. Consequently, there will be fewer immigrant workers in the Saudi labor market as most immigrants lives alone in the host country. Overall, the hump-shaped IRF of the immigrant ADR reflects the magnitude in the dynamic interaction between immigrant and domestic populations. However, during the first fifteen years ahead, the positive responses of immigrant ADR decrease monotonically to the DEL shocks. Such IRF becomes negative, by a small magnitude, during the next twenty-five years ahead and converges to zero. The explanation of such effects is simply because such shocks increase the overall number of the immigrant workforce. Consequently, this reduces the immigrant ADR continuously as they keep their family members in their native countries. By combining both DEL shocks on Saudi ADR and SWP shocks on immigrant ADR,

[32] By considering the OECD countries, Ortega and Peri (2009) emphasize that there is no evidence of crowding-out of natives by the immigrants.

the effects of their respective IRF show that the complementarity process between immigrant and the native population dominates in the short and medium terms. However, in the long term, the effects indicate that the substitutability process prevails. This means that the human capital of immigrants can positively adjust the disequilibrium, in the short and medium term, between native and immigrant workforce in the domestic labor market and negatively in the long term. The first adjustment process is due to complementarity and the second process is due to substitutability.

A positive shock of Saudi ADR leads to a volatile GDP growth (Figures B.4). In the short-run, a positive shock of DEL generates volatile impacts on GDP growth; but in the long-run horizon, the effect is positive. Such an empirical outcome establishes some previous empirical assertions as in Ortega and Peri (2009) and Peri (2016) differently. In the short and medium-term, the reactions of GDP growth to both shocks of native and immigrant working-age populations move unsteadily in opposite directions. Still, in the long-run both effects become moderately positive. This result could mean that the increased qualification and learning-by-doing mechanism among immigrants and natives contribute to improving the GDP. Summing up, the IRF of GDP growth cannot produce hump-shaped responses since the adjustments are oscillatory; the mechanisms behind these behaviors that amplify their propagation are from many channels such as the learning-by-doing, labor adjustment costs, and redistribution.

Table 4. Structural variance decomposition analysis

	TIT			SWP			DEL			DOS		
	h=10	h=25	h=50	h=10	h=25	h=50	h=10	h=25	h=50	h=10	h=25	h=50
ΔCAY	61.40	49.40	48.74	3.40	7.62	7.91	32.45	38.01	38.35	2.75	4.97	5.00
Δs_ADR	0.03	0.04	0.04	23.05	22.67	22.96	72.65	69.41	69.15	4.27	7.88	7.85
Δns_ADR	2.69	2.37	2.32	15.05	21.22	21.19	69.15	63.73	63.80	13.11	12.68	12.69
Δg_GDP	13.43	13.32	13.31	2.35	2.49	2.51	5.24	5.73	5.76	78.98	78.46	78.42

Note: Variations in the row variables are explained by structural shocks in column variables. The numbers are in percent for 10, 25 (one generation) and 50 periods (two generations) ahead.

Using structural VAR factors, the variance decomposition measures the contribution of each structural shock source to the forecast error variance in predicting each endogenous variable over a temporal horizon. The variance decomposition (Table 4) displays that, during the horizon of the two next generations, the structural disturbance in DEL explains approximately 69% and nearby 38% of the variations in the native ADR and CA-to-GDP, respectively. In the long-term horizon, the shock in SWP explains merely 21% of the changes in the immigrant ADR, much weaker than the explanation level of Saudi ADR variation by the shock in the DEL. Furthermore, the shock in SWP explains only around 7% of the fluctuations in CA-to-GDP. In comparison, the shock in the DEL elucidates around 38% of the variation in CA-to-GDP. Parallelly, these respective shocks of native and immigrant workforce explicate nearby 2.5% and 6% of the GDP growth fluctuations, respectively. In the ten years ahead, we can also detect that the structural shock of real domestic supply to the forecast error variance explains approximately 13% of immigrant ADR changes, but only approximately 4% of the variation in Saudi ADR. Furthermore, the shocks in TIT explain about 2.3% and only 0.04%, respectively, of the forecast error variance in immigrant and native ADRs. Additionally, these shocks explain almost 13% of the changes in GDP growth. Overall, the CA-to-GDP variations and the Saudi ADR changes are mostly due to the DEL shocks.

6. Conclusion

By distinguishing the immigrant age dependency rate (ADR), we highlight the dynamic effects of the immigrant working-age population on CA-to-GDP processes, native active age population, and GDP growth. By specifying a structural vector autoregressive (SVAR) framework, we evaluated the impacts of domestic and international shocks on the underlying variables of the VAR model. During a long-term period of less than a generation, the effects of the SWP and DEL shocks on the CA-to-GDP moved in opposite directions. But, in the medium term, the cumulative positive effects of DEL shocks dominate and cancels out the cumulative negative effects of SWP. Also, the positive real domestic supply shocks have large positive impacts on the CA-to-GDP, generating a hump-shaped reaction. These responses decay very slowly in the long-run.

We find a negative hump-shaped reaction of Saudi ADR to immigration policy shocks during a generation. When the shocks emanate from immigrants' working-age, there is a complex mechanism from the complementarity process to the substitutability process between the immigrant and Saudi workforce. The first complementarity process can be because the flow of immigrant workers can enlarge the labor market prospects of Saudi working-ages for some specific specialties and skills. The second substitutability process can be because native employment has progressive adverse effects on the immigrant workforce in the Saudi labor market. However, the immigrant inflows do not strongly affect the established native workers but could affect potential native workers mainly during bad economic cycles. According to our empirical results and as the immigration level is highly regulated by the Saudi government, the immigrants appear to be more complements than substitutes to Saudi workers.

Conversely, the positive shocks in domestic working-age population growth generate a positive hump-shaped reaction of immigrant ADR growth. When the shocks emanate from Saudi working-age population, there is a complex substitutability process to the complementarity between Saudi and immigrant working-age population. Consequently, there will be fewer immigrant workers in the Saudi labor market since the majority of immigrants lives alone in the host country.

By combining both the DEL shocks on Saudi ADR and SWP shocks on immigrant ADR, the effects of their respective IRF show that the complementarity process between the immigrant and the native population dominates in the short and medium terms. However, in the long term, the effects indicate that the substitutability process prevails. This means that the immigrant human capital can positively adjust the disequilibrium in the short and medium term, through a complementary process, between native and immigrant workforce in the domestic labor market, and adjust negatively, through a substitutability process in the long term.

In short and medium-term, the reactions of GDP growth to shocks of native and immigrant working-age populations move unsteadily in opposite directions. However, in the long-run, both effects become moderately positive. This outcome could mean that the increased qualification and learning-by-doing mechanisms among immigrants and natives contribute to improving the GDP. Moreover, the variance decomposition displays that overall, during the horizon of the two next generations, the CA-to-GDP variations and the changes in Saudi ADR are mostly due to the structural shocks in the DEL.

An important implication of our findings is that the policymakers and government institutions could improve job opportunities for the native workforce by considering the dynamic processes of complementarity/substitution of the immigrant to native workers. Additionally, the labor strategies of the private sector have to restructure the labor market conditions by matching the skills by age-groups between immigrants and natives and focusing on more productive labor factor than the cheap workforce. The success of such strategies depends on the complementarity or substitution intensities between natives and immigrant workers. Furthermore, the Saudi economy will gain more by institutionalizing familial grouping for immigrants as in Western or European countries. Such a policy would reduce the remittance outflows, but it requires adjusting and regulating immigrant wages to the Saudi wages in private and public sectors. Overall, the Saudi government, in collaboration with the relevant stakeholders, has to find an equilibrium between Saudi and immigrant laborers by breaking down the duality of the labor market through the progressive elimination of the sponsorship system, and by increasing the productivity of labor and enhancing the quality of life for all members of the society.

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Appendix 1. Tables

Tables A. Correlation: CA-to-GDP and age-population sharing from 1974 to 2016

Correlation	cayr	g_gdp_r	0-24_ns	0-24_s	0-24_to	25-64_ns	25-64_s	25-64_to	65+_ns	65+_s	65+_to
Cayr	1										
g_gdp_r	0.4848 (0.0011)	1									
0-24_ns	0.2392 (0.1271)	0.0027 (0.9862)	1								
0-24_s	-0.4061 (0.0076)	-0.3299 (0.0328)	0.4205 (0.0055)	1							
0-24_to	-0.2273 (0.1476)	-0.3114 (0.0447)	0.7095 (1.4E-07)	0.9263 (1.5E-18)	1						
25-64_ns	-0.2519 (0.1075)	-0.0065 (0.9673)	-0.9991 (1.1E-56)	-0.3908 (0.0105)	-0.6879 (4.8E-07)	1					
25-64_s	0.3987 (0.0089)	0.3367 (0.0292)	-0.4522 (0.0026)	-0.9988 (5.4E-54)	-0.9397 (3.1E-20)	0.4236 (0.0052)	1				
25-64_to	0.2072 (0.1879)	0.3117 (0.0444)	-0.7386 (2.3E-08)	-0.9059 (1.6E-16)	-0.9984 (1.8E-51)	0.7189 (8.2E-08)	0.9218 (4.6E-18)	1			
65+_ns	0.3845 (0.0119)	0.0805 (0.6124)	0.4717 (0.0016)	-0.4161 (0.0061)	-0.1039 (0.5126)	-0.5084 (0.0006)	0.3785 (0.0134)	0.0511 (0.7480)	1		
65+_s	0.2246 (0.1527)	-0.0717 (0.6518)	0.5508 (0.0002)	-0.2146 (0.1723)	0.0903 (0.5693)	-0.5773 (6.3E-05)	0.1664 (0.2922)	-0.1450 (0.3594)	0.8270 (1.5E-11)	1	
65+_to	0.2502 (0.1100)	-0.1197 (0.4502)	0.7427 (1.8E-08)	0.0003 (0.9983)	0.3385 (0.0283)	-0.7652 (3.6E-09)	-0.0475 (0.7650)	-0.3914 (0.0103)	0.8373 (4.8E-12)	0.9391 (3.6E-20)	1

Notes: The series cayr and g_gdp_r correspond to the current account-to-GDP ratio and real economic growth, respectively. The lower matrix shows the correlation coefficients and their significance level in terms of the p-value. The variable ADR stands for Age Dependency Rate, defined as the ratio between youth and old (0-24;65+) groups and the group of working-age (25-64). It is constructed for Saudi (s_ADR), immigrants (ns_ADR) and all populations (to_ADR). The p-values are in parentheses.

Correlation	cayr	g_gdp_r	ns_ADR	s_ADR	to_ADR
cayr	1				
g_gdp_r	0.4848 (0.0011)	1			
ns_ADR	0.2644 (0.0906)	0.0202 (0.8990)	1		
s_ADR	-0.4748 (0.0015)	-0.3433 (0.0260)	0.3351 (0.0301)	1	
to_ADR	-0.1816 (0.2498)	-0.2947 (0.0581)	0.7545 (7.9E-09)	0.8466 (1.6E-12)	1

Table B. Descriptive statistics with 42 Observations (1974-2016)

	cayr	g_gdp_r	ns_ADR	s_ADR	to_ADR
Mean	0.06001	-0.00354	0.58056	2.11151	1.50025
Median	0.05313	0.00271	0.51146	2.32937	1.56544
Std. Dev.	0.16079	0.04881	1.26244	2.71491	2.12779
Skewness	0.25236	-1.10866	0.33062	1.03588	0.74721
Kurtosis	1.77051	4.06558	0.20409	0.46065	0.35777
Jarque-Bera (P-value)	3.09117 (0.21319)	10.59086 (0.00501)	49.48223 (0.00000)	4.61254 (0.09963)	0.93216 (0.62746)

Tables C.1. KPSS stationarity tests

KPSS	cayr	g_gdp_r	ns_ADR	s_ADR	to_ADR
LM Stat.[a]	0.1979 (C, T, 3)	0.5639 (C, 2)	0.2059 (C, T, 2)	0.2392 (C, T, 4)	0.1868 (C, T, 4.4)
HAC variance [b]	0.077865	0.003791	0.197638	0.030754	0.032179

KPSS	dcayr	dg_gdp_r	d(ns_ADR)	d(s_ADR)	d(to_ADR)
LM Stat.	0.2954*** (C, 4.7)	0.0734*** (C, T, 4)	0.1817*** (C, 2)	0.0942*** (C, T, 3)	0.4158*** (C, 5.6)
HAC variance	0.007907	0.000695	0.027490	0.000533	0.003056

Notes: [a] Between the parentheses, we have the exogenous variables in the KPSS test equation, Constant C and Linear trend T. The last number in the parentheses corresponds to Newey-West automatic bandwidth using Quadratic Spectral kernel. When this number is an integer, it means that we use a specified lag truncation parameter. *** stands for 1% significance levels as in Table 1 of KPSS paper (1992).

[b] HAC variance corresponds to the heteroskedasticity and autocorrelation consistent long-run variance using the quadratic spectral window, which leads to a higher rate of consistency (Kiefer and Vogelsang 2005; Hobijn, Franses and Ooms 2004).

Table C.2. Zivot-Andrews (ZA) unit root tests

ZA	ns_ADR	s_ADR	d(ns_ADR)	d(s_ADR)
ZA Stat.	-4.1488	-3.2308	-4.6885**	-9.5658***
Break point	1991	1999	1991	1999
Critical value	-5.34	-4.93	-4.42	-5.34

Note: As suggested by one of the reviewers, we run the Zivot-Andrews unit root test taking into account the presence of a structural break as displayed in the plot of s_ADR. *** and ** stand for significance levels at 1% and 5%, respectively.

Notes on Tables D

The ARDL approach introduced and revised by Pesaran et al. (2001) is mostly used in empirical research when the regressors have a different order of integration or are all I(1) or all I(0). The ARDL bound model is based on the conditional error correction (CEC) model, which is formulated as follows (PSS, 2001)

$$\Delta y_t = a_0 + a_1 t + a_2 D_t + b_0 y_{t-1} + \sum_{i=1}^{k} b_i\, x_{i,t-1} + \sum_{i=1}^{p-1} \psi_i' \,\Delta z_{t-i} + \omega' \Delta x_t + u_t$$

where y_t is a random scalar process that is conditionally modeled given the k-vector of random variables x_t and the past values $z_{t-i} = (y_{t-1}, x_{t-i}')'$, and u_t is the error term. The deterministic components are the intercept and the trend t, which are associated to a drift-parameter a_0 and a time-trend-parameter a_1, respectively. When the deterministic components contribute to the error correction term, they are implicitly projected onto the span of the cointegrating vector, implying that a_0 and a_1 in the CEC model must be restricted.

Table D1: Bounds test for cointegration with break-points (k=3)

	Restricted intercept and no trend (case 2)	Unrestricted intercept and restricted trend (case 4)	Unrestricted intercept and unrestricted trend (case 5)
Calculated F-Statistic	3.420970	3.058527	3.738243
Calculated t-Statistic			-2.725569

Notes: There is no t-statistic for the cases 2 and 4 due to the restrictions on the deterministic coefficients. We use the Akaike's Information Criteria (AIC) to select the lag orders of the ARDL model.

Table D2: Narayan Critical values (k=3, n=45)

	Case 2		Case 4		Case 5	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Significance at 5%	3.078	4.023	3.822	4.714	4.450	5.560
Significance at 1%	4.270	5.412	5.150	6.280	6.053	7.458

Notes: Narayan (2005) does not consider the critical value (CV) bounds of the t-Statistic for cases 1,3 and 5. For the case 5, PSS (2001) provide that, at 5% of significance, the lower stationary bound and the upper bound are -3.410 and -4.160, respectively; and at 1% of significance -3.960 and -4.730, respectively. If the computed F-Statistic is higher than the upper bound of CV, then the null of no cointegration is rejected. The lower bound is based on the assumption that all of the variables are I(0), while the upper bound that all of the variables are I(1).

Table D3: Diagnostic tests

	Case 2		Cases 4 and 5	
	Statistic	Prob.	Statistic	Prob.
Autocorrelation	0.963068	0.3925	0.879632	0.4250
Heteroskedasticity	1.336502	0.2682	1.499222	0.2019
Ramsey Reset	1.592651	0.2158	1.632408	0.2106

Notes: The computed statistics of the autocorrelation Lagrange Multiplier (LM), heteroskedasticity and Ramsey Reset tests are from F-statistic. Cases 4 and 5 have the same model specification, but their null hypothesis in testing for cointegration are different (see footnote 3).

Table 1: VAR Lag Order Selection Criteria

Lag	$Log\ L$	LR	FPE	AIC	SC	HQ
0	283.76	NA	$6.91\text{E}-12$	-14.35	-14.18	-14.28
1	366.12	143.59^{*}	$2.31\text{E}-13^{*}$	-17.75^{*}	-16.89^{*}	-17.44^{*}
2	379.54	20.65	$2.71\text{E}-13$	-17.62	-16.08	-17.07
3	390.26	14.30	$3.82\text{E}-13$	-17.35	-15.13	-16.55
4	405.34	17.00	$4.63\text{E}-13$	-17.30	-14.40	-16.26

Note: The $*$ indicates lag order selected at 5% of significance level by the criterion of the statistics: sequential modified likelihood ratio (LR), Final prediction error (FPE), Akaike information (AIC), Schwarz information (SC) and Hannan-Quinn information (HQ).

Table 2: VAR Residual Serial Correlation LM Tests

Lag	$LRE^{*}-stat.$	Df	$Prob.$	$Rao\ F-stat$	Df	$Prob.$
1	19.65	16	0.236	1.26	(16,92,3)	0.24
2	17.46	16	0.356	1.11	(16,92,3)	0.36

Note: The $*$ indicates the corrected Likelihood Ratio statistic by Edgeworth expansion.
The null hypothesis corresponds to no serial correlation at lag h.

Table 3.1 Residual variance-covariance matrix

	res_dcay_t	$res\_ds\_adr_t$	$res\_dns\_adr_t$	$res\_dg\_gdp_t$
res_dcay_t	0.00919	0.00001	0.00033	0.00131
$res\_ds\_adr_t$	0.00001	0.00023	-0.00004	-0.00002
$res\_dns\_adr_t$	0.00033	-0.00004	0.00008	0.00014
$res\_dg\_gdp_t$	0.00131	-0.00002	0.00014	0.00167

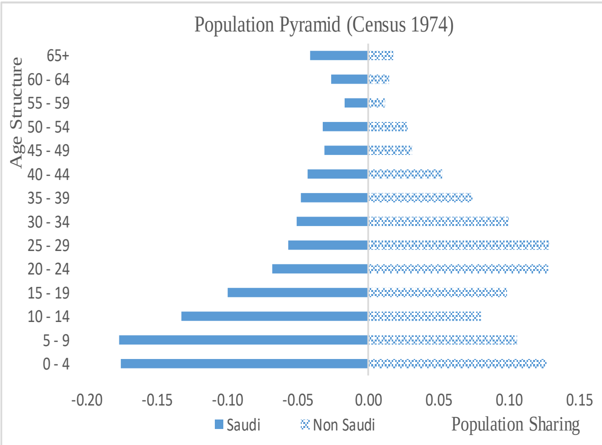
Table 3.2 Residual correlation matrix

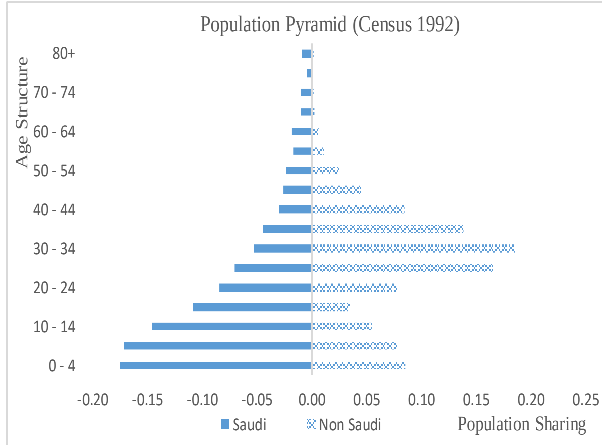
	res_dcay_t	$res\_ds\_adr_t$	$res\_dns\_adr_t$	$res\_dg\_gdp_t$
res_dcay_t	1.00000	0.00556	0.39096	0.33449
$res\_ds\_adr_t$	0.00556	1.00000	-0.31024	-0.02763
$res\_dns\_adr_t$	0.39096	-0.31024	1.00000	0.38270
$res\_dg\_gdp_t$	0.33449	-0.02763	0.38270	1.00000

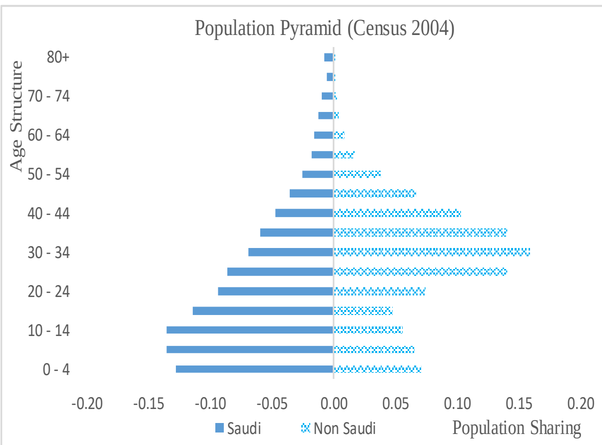
Appendix 2. Figures

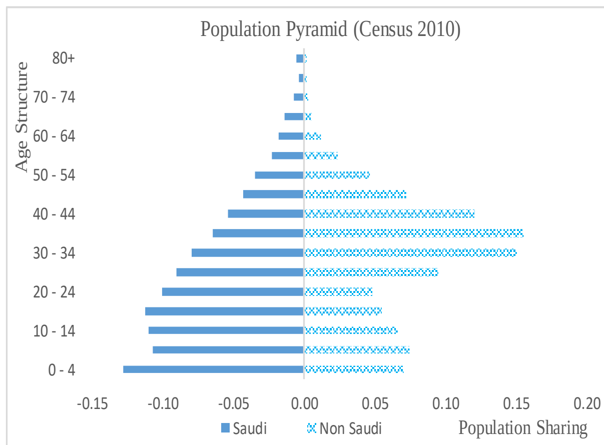
Figures A. Bi-Population Pyramid by Census in Saudi Arabian Economy from 1974 to 2016

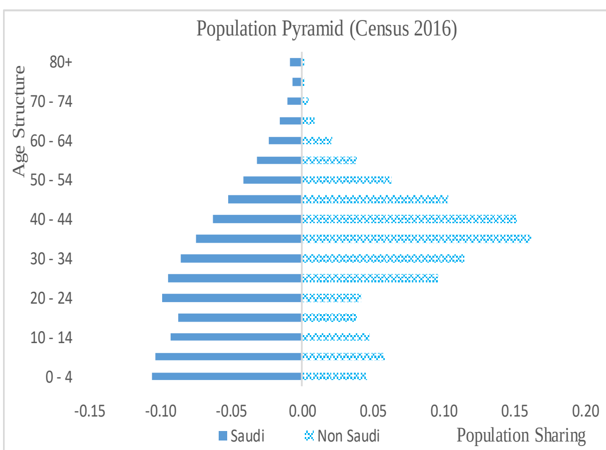
(Authors processing from the demographic censuses of General Authority for Statistics, Riyadh, KSA)



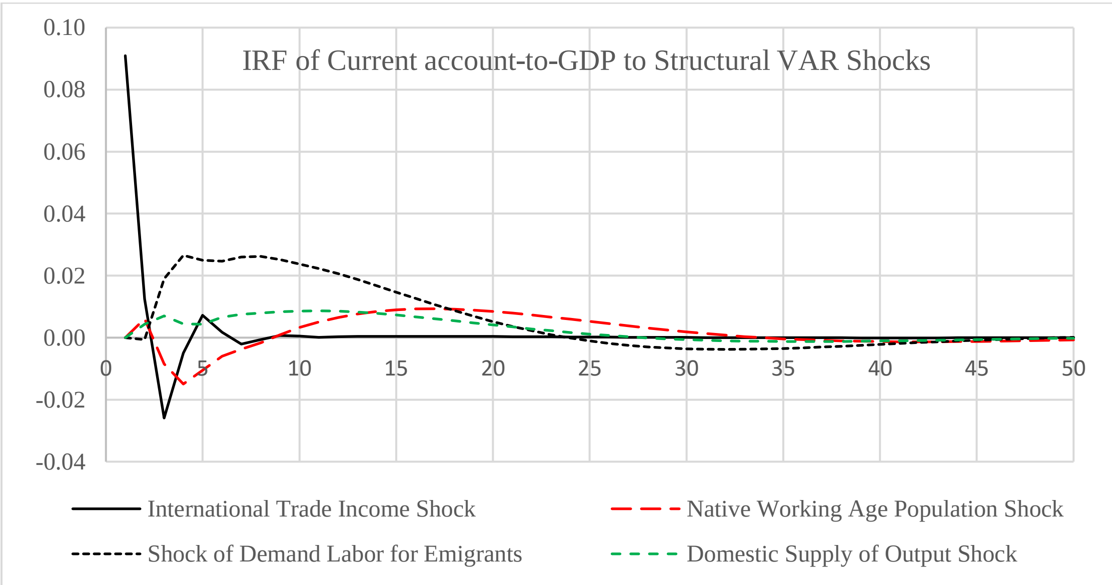




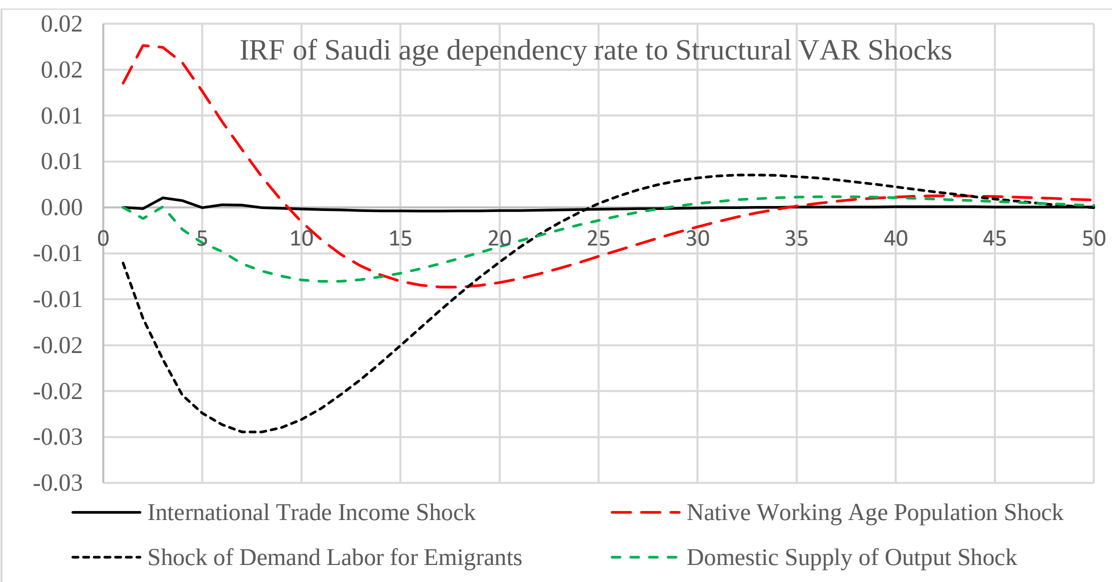




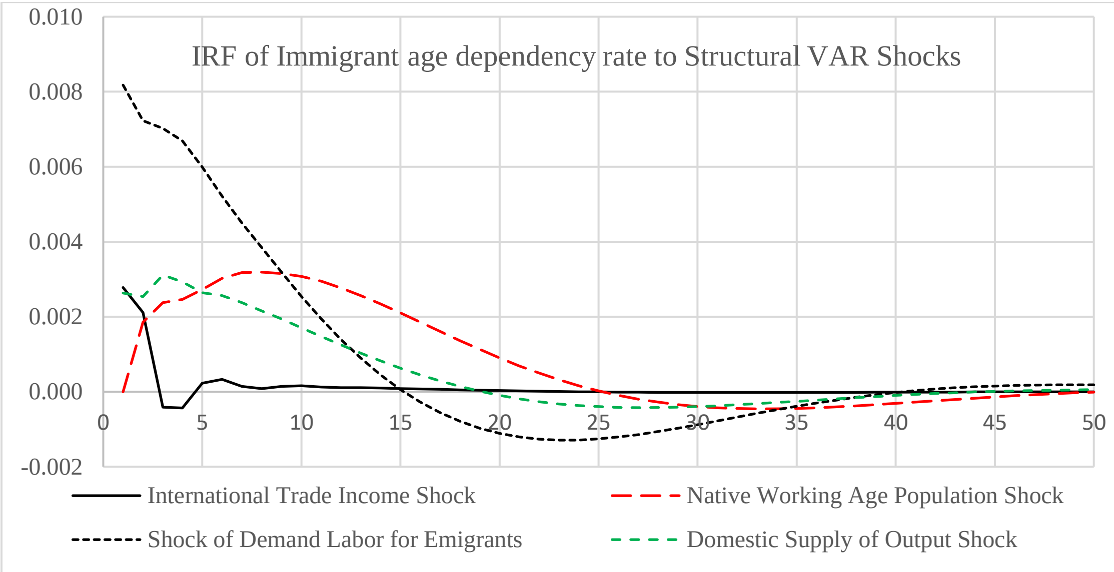
Figures B.1. Impulse responses functions (IRF) of the Current account-to-GDP ratio



Figures B.2. Impulse responses functions (IRF) of Saudi Age dependency rate



Figures B.3. Impulse responses functions (IRF) of Immigrant Age dependency rate



Figures B.4. Impulse responses functions (IRF) of the Economic growth